UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF DICKINSON DAM SPILLWAY

Hydraulic Laboratory Report No. Hyd.-267

RESEARCH AND GEOLOGY DIVISION

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

DECEMBER 30, 1949

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FOREWORD

Hydraulic model studies of the Dickinson Dam Spillway, a part of the Missouri River Basin Project, were conducted in the Hydraulic Laboratory of the Bureau of Reclamation at Denver, Colorado, during the period January 20, 1948, to May 5, 1949.

The final plans, evolved from this study, were developed through the cooperation of the staffs of the Spillway and Outlet Section No. 1 and the Hydraulic Laboratory.

During the course of the model studies, Messrs. D. C. McConaughy and L. M. Stimson of the Spillway and Outlet Section No. 1 frequently visited the laboratory to observe the model tests and to discuss test results.

These studies were conducted by G. L. Beichley under the direct supervision of W. E. Wagner, A. J. Peterka, and J. N. Bradley.

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Laboratory Report No. 267
Hydraulic Laboratory
Compiled by: G. L. Beichley
Reviewed by: A. J. Peterka

Subject: Hydraulic model studies of Dickinson Dam Spillway.

SUMMARY

Hydraulic model studies were made on a 1:36 scale model of Dickinson Dam Spillway for the purpose of developing and checking the hydraulic design by means of performance tests. Data and notes were taken on the flow in the spillway approach, the spillway itself, the stilling-basin, and on flow in the river channel below the structure.

More specifically, tests were conducted to check flow conditions in the approach to the spillway, Figure 9, and to determine the characteristics of the spillway both as to capacity and pressures on the spillway crest and face, Figures 10 and 11. The spillway was also tested for heads higher than those proposed for the prototype to determine whether the crest could be reshaped to provide a greater discharge coefficient, Figure 12. These tests showed the original crest shape to be satisfactory and that a greater spillway coefficient could not be expected without modifying the entire spillway profile by increasing the height of free fall.

Performance tests on three different stilling-basins, Figure 4, were made to determine the most economical proportions and dimensions of the basin, the end sill, and the wing-walls at the end of the basin, which would provide the least amount of erosion at the downstream end of the basin. Scour patterns were used to evaluate the effectiveness of each design, Figures 18, 22, 26, and 28. Water-surface profiles in the stilling-basin were recorded for the original and recommended design, Figures 17 and 27, and stability tests were made to determine the lowest tailwater elevation possible before the jump was swept off the apron, Page 8.

Tests on the original design, Figure 4(a), showed that the performance of the structure, in general, was satisfactory, Figures 14, 15, and 16, but that it might be possible to obtain equal stilling-basin performance by using a sloping apron, Figure 4(c). Tests showed that the erosion below the sloping apron was not excessive, Figure 28, and that the tailwater elevation could be lowered 4.2 feet below the expected low elevation before the jump was swept off the apron, Page 8. This modified apron used with 45° wing-walls to replace the 90° walls at the end

of the apron showed an improved scour pattern, Figures 18 and 23. Details of this design, recommended for prototype use, are shown in Figures 3 and 4(c). Figures 8, 24, 25, and 26 show the operation of the design recommended for prototype construction.

INTRODUCTION

Dickinson Dam is a part of the Heart River Unit of the Missouri River Basin Project. It is located on the Heart River in Southwestern North Dakota, Figure 1. The dam, Figure 2, is an earth-fill structure approximately 2,300 feet long at the crest and has a maximum height of approximately 40 feet above the channel bed.

A concrete spillway, Figure 3, 200 feet wide, is located near the right abutment. The spillway has an uncontrolled crest and is designed to pass 33,200 second-feet at maximum reservoir elevation 2428.9, which corresponds to a discharge of 166 second-feet per lineal foot of spillway width. The spillway crest is at elevation 2416.5, 12.4 feet below the maximum water surface of the reservoir, and the spillway approach channel is excavated to 4.5 feet below the crest.

The intake to the outlet works is located in the left wing-wall of the spillway approach channel. The approach channel to the outlet works is excavated through the spillway approach channel at elevation 2404, 12.5 feet below the spillway crest.

As originally designed, the vertical fall from spillway crest to the apron was 36 feet and the distance from the crest line to the start of the horizontal apron was 201.12 feet. The length of the horizontal apron was 57 feet or about 2.4 (d_2), where d_2 is the expected depth of water at the downstream end of the stilling-basin when the spillway is discharging 33,200 second-feet. Chute blocks were installed on the downstream end of the spillway face, where it joined the horizontal apron and a dentated sill was placed on the downstream end of the apron, as shown in Figure 4(a). The chute blocks and the dentated sill were 4 feet high or approximately the height of the expected d_1 dimension, where d_1 is the depth of the water normal to the spillway face just upstream from the hydraulic jump for a discharge of 33,200 second-feet.

Approximately 2,600 feet downstream from the spillway stilling-basin is a concrete overflow dam, Figure 5, referred to as a diversion dam on the tailwater curves of Figure 6. From the stilling-basin to the diversion dam the prototype river bottom is sand covered with a 10-foot layer of silt. It is possible that at some future date the diversion dam may be removed; in which case the layer of silt would eventually be washed away. For this reason two different tailwater elevations are possible for each discharge, as indicated by the two tailwater curves of Figure 6. Hereafter in this report, the tailwater elevation with the diversion dam in place will be referred to as high tailwater; with the diversion dam removed, low tailwater.

THE MODEL

The model shown in Figure 6 and by photograph in Figures 7 and 8, is a 1:36 scale reproduction of the spillway and surrounding area and was constructed and tested in the Bureau of Reclamation Hydraulic Laboratory at the Denver Federal Center. The reservoir was reproduced for a distance of 400 feet upstream from the spillway and the lower river channel for a distance of 425 feet downstream from the spillway apron.

Topography in the reservoir area of the model was molded of concrete mortar placed on metal lath. Model concrete surfaces simulating nonconcrete surfaces of the prototype such as topography were given a brush finish, while model concrete surfaces simulating prototype concrete surfaces were given a smooth finish. The concrete spillway approach apron, spillway crest and face, and stilling-basin apron were molded in cement mortar to sheet-metal templates. A 1-inch-wide strip of sheet metal was fastened to the template located on the centerline of the spillway and the piezometers, which consisted of small-bore copper tubing, were inserted normal to the surface determined by the metal strip and dressed flush. Thus, the piezometer openings were on a smooth, polished metal strip which conformed exactly to the spillway profile.

Chute blocks and the dentated end sill were made of wood and sanded smooth. The approach wing-walls and spillway training-wall surfaces were of sheet metal. The 90° wing-walls of the original stilling-basin design were constructed as a part of the model test box enclosing the tailwater area, while the 45° wing-walls of the second and recommended stilling-basin designs were of 3/4-inch plywood extending out into the tailwater area. Walls and floors of the boxes enclosing the tailwater area as well as the reservoir area were covered with metal sheets soldered together to provide a watertight container.

Since the topography downstream from the prototype stilling-basin would be subject to erosion below the maximum expected tailwater elevation of approximately 2404.8, an erodible bed below this elevation was required in the model in order to determine the erosion tendencies that would be present in the prototype. Thus, the topography below elevation 2406 in the model was molded in sand, while the topography above this elevation was molded in concrete similar to that in the reservoir area. A sample of the sand used throughout the erodible bed was analyzed and found to be as shown in the following table:

Sieve Analysis of Sand Sample

Passing a No. 4 sieve	100 percent
Passing a No. 8 sieve	91 percent
Passing a No. 16 sieve	63 percent
Passing a No. 30 sieve	27 percent
Passing a No. 50 sieve	3 percent
Passing a No. 100 sieve	0 percent

The riprap downstream from the prototype stilling-basin was reproduced with sand similar to that used in the remainder of the erodible bed, rather than with a coarser aggregate, in order to more easily and accurately determine the erosion tendencies in the model. It was thus assumed that if the erosion pattern was satisfactory with the sand in place, the pattern would also be satisfactory if riprap protection was also provided in the prototype. Riprap on the side slopes of the prototype stilling-basin was reproduced in the model with 1-1/2-inch coarse rock rather than with sand because of the inherent tendency of the sand to slump when wet.

Water was supplied to the model by a portable 6-inch pump through an 8-inch line. Discharges were measured by an 8-inch orifice-venturi meter placed in the supply line. The reservoir and tailwater elevations were measured by a hookgage and pointgage, respectively, located in the model as shown in Figure 6. The tailwater elevation was controlled by a gate at the extreme downstream end of the model. The proper tailwater setting was determined from the tailwater curves shown in Figure 5. Crest pressures were measured by means of 15 piezometers placed as described above. Water-surface profiles were measured by use of a pointgage sliding on a horizontal guide rail parallel to the spillway centerline at a distance of about one-third the spillway width from the right-hand training-wall, as shown in Figures 6 and 7(c).

THE INVESTIGATION

The investigation was primarily concerned with the performance of the spillway discharging its maximum designed discharge of 33,200 second-feet, which corresponds to 166 second-feet per lineal foot of spillway width with a head of 12.4 feet on the crest, since this flow created the most severe conditions throughout the structures. To a lesser degree discharges of 10 and 20 thousand second-feet were investigated in order to be certain that the structure operated as intended over the entire discharge range. The investigation included the testing of the spillway approach, spillway crest, original stilling-basin design, and two other stilling-basin designs which were modifications of the original. In the modified designs the apron was changed from horizontal to sloping and the stilling-basin wing-walls were changed from a 90° to a 45° angle.

Spillway Approach

The characteristics of the spillway approach are shown in Figures 4(a) and 7(b) and flow conditions for a range of discharges were observed in this area. Flow conditions for a discharge of 33,200 second-feet are shown in Figure 9(a). For this discharge a slight drawdown and disturbance was observed at the upstream ends of the approach wing-walls. The drawdown around the left wall is shown close up in Figure 9(b) and was slightly greater than that occurring around the right wall. As the disturbance was minor and had no effect on the performance of the structure no change in design is recommended in this area.

Spillway Crest

The spillway was rated by model tests to determine its capacity and to determine the value of the coefficient "C" in the equation:

$$Q = CLH^{3/2}$$

The profile of the spillway crest is shown in Figures 3 and 4(a). The capacity of the spillway was found to be 32,600 second-feet at maximum reservoir elevation 2428.9 with a corresponding coefficient of 3.74, as shown in Figure 10. Other headwater-discharge relations and headwater-coefficient relations for the entire range of operation are also shown in Figure 10. Since the actual discharges proved to be very close to the flows predicted by the designers, the crest structure was satisfactory from the standpoint of discharge.

Pressures on the spillway crest and on the spillway face were found to be positive for all discharges. The manometer board showing the model pressures while the spillway was discharging 33,200 second-feet was photographed and is shown in Figure 11.

The plus pressures on the crest and immediately downstream, shown in Figure 11, indicate that some of the pressure head causing flow over the crest is not being fully utilized in producing flow. It was believed that it might be possible to reshape the crest to obtain a lower positive pressure or even a subatmospheric pressure and thereby increase the discharge coefficient. Thus, the maximum flood could be passed at a lower reservoir elevation and the height of the dam or the spillway length could be reduced. The one drawback to this procedure appeared to be the relatively low drop from the spillway crest to the flat portion of the spillway profile at about Station 8+14, Figure 12. This drop amounted to only 4.5 feet and for discharges above 7,000 second-feet, Figure 10, the head on the crest was greater than the drop over the spillway crest. As a result of this condition, discharges for heads greater than 4.5 feet might be noticeably affected by the lack of a free fall condition below the crest. To determine how great this effect was, tests were made at higher heads than would be expected on the prototype and pressures were measured. The results are plotted in Figure 12. These curves show an increase in pressure below the crest with increasing head. The discharge coefficient, however, remains constant at about 3.74, indicating that little could be gained by reshaping the crest unless the elevation of the spillway profile could be lowered substantially, beginning at Station 8+12. Since this was not practical in the prototype, no change in the spillway crest shape is recommended.

Spillway Stilling-basin

The original design--Horizontal apron. The original design of the spillway stilling-basin used a horizontal apron, as shown in Figure 4(a) and by photograph in Figure 13. The length of the apron was approximately

2.4 (d_2) where d_2 is the depth of water over the end of the apron for the maximum discharge. The height of the chute blocks and dentils were approximately the d_1 dimension where d_1 is the depth of water normal to the spillway face just upstream from the start of the hydraulic jump for the maximum discharge.

The operation of the stilling-basin was observed for discharges of 10, 20, and 33.2 thousand second-feet. Each discharge was run with high and low tailwater elevations.

The water surface in the stilling-pool was nearly horizontal and quite smooth even for the maximum discharge, as shown in Figures 14, 15, and 16. The stilling-basin depth was more than adequate to produce a satisfactory hydraulic jump as indicated by the water-surface profile of Figure 17.

Model scour tests of 2 hours' duration were run for the maximum discharge with both high and low tailwater. Maximum scour occurred near the left bank just downstream from the end sill, as shown by the photographs of Figure 18. In this area the water leaving the apron was directed to the surface by the end sill, causing the otherwise still water on the left to be drawn in under the main flow in the form of a subsurface eddy. This induced flow was more or less parallel to the end sill for a short distance; then it was gradually turned downstream by the main flow and caused the erosion illustrated in Figure 19(a). Because of the proximity of the bank below the right-hand side of the stilling-pool, there was no violent eddy and a different type of flow action occurred near the apron corner on the right. In this area a ground roller caused by the flow over the end sill deposited sand at the end of the apron, thereby establishing protection from undermining, as illustrated in Figure 19(b). The performance of this stilling-basin was entirely satisfactory and would have been recommended for use in the prototype structure except that it was believed that a less costly apron could be devised which would perform equally well.

Second design--Sloping apron. As a result of the tests on the horizontal apron, it was apparent that the apron was more than adequate to handle large spillway discharges and it was believed that a sloping apron, which would reduce the amount of excavation in the stilling-basin, would provide ample protection against dangerous erosion. The second basin tested had an apron which sloped downward in the downstream direction on an 8:1 slope. The downstream end of the apron remained at the same station and elevation as that of the original design, while the upstream end was raised to join the spillway face with a vertical curve, as shown in Figure 4(b). This change in apron design made necessary slight alterations in detail of the dentated end sill and chute blocks, which are also shown in Figure 4(b). The 90° wing-walls at the end of the apron were changed to 45°, Figure 4(b), for the purpose of reducing the eddy action at the apron corners and thereby reducing the riverbed erosion. Tests on other previously tested models had shown this to be an effective procedure. Figure 20 is a photograph showing the sloping apron and 45° wing-walls installed in the model.

Flow through the stilling-basin for discharges of 10, 20, and 33.2 thousand second-feet was observed and for each discharge with both high and low tailwater the jump formed in the stilling-basin as desired. Flows of 10, 20, and 33.2 thousand second-feet operating with low tailwater are shown in Figure 21. Operation with high tailwater was found to be less critical than with low tailwater, and consequently the basin was tested primarily for low-tailwater conditions.

A 2-hour model scour test was run with low tailwater and the spillway passing 33,200 second-feet. A considerable quantity of sand was carried away from along the entire length of the end sill, as shown in Figure 22(a). In the prototype this might eventually result in undermining of the structure and the need for costly repairs. No further tests were made on this design, since it was felt that the stilling-basin could be modified to produce a more acceptable erosion pattern.

Upon analyzing the sloping apron design to determine the cause of the undesirable scour pattern, it was believed that the slope of the upstream face of the end sill was too flat and that the dentils on the sill were too low to completely turn the oncoming water toward the surface. Evidently, the main flow continued in a downward direction after leaving the apron, causing erosion close to the end sill and for quite some distance downstream, as illustrated in Figure 22(b). It was believed that a modification of the dentated end sill would correct this condition.

Recommended design--Sloping apron. The dentated end sill of the recommended design was raised 1.19 feet higher than that of the second design, making the sill identical in size and detail to that of the original design, as shown in the drawing of Figure 4(c) and the photograph of Figure 23. Other features of the previously discussed second design remained unchanged.

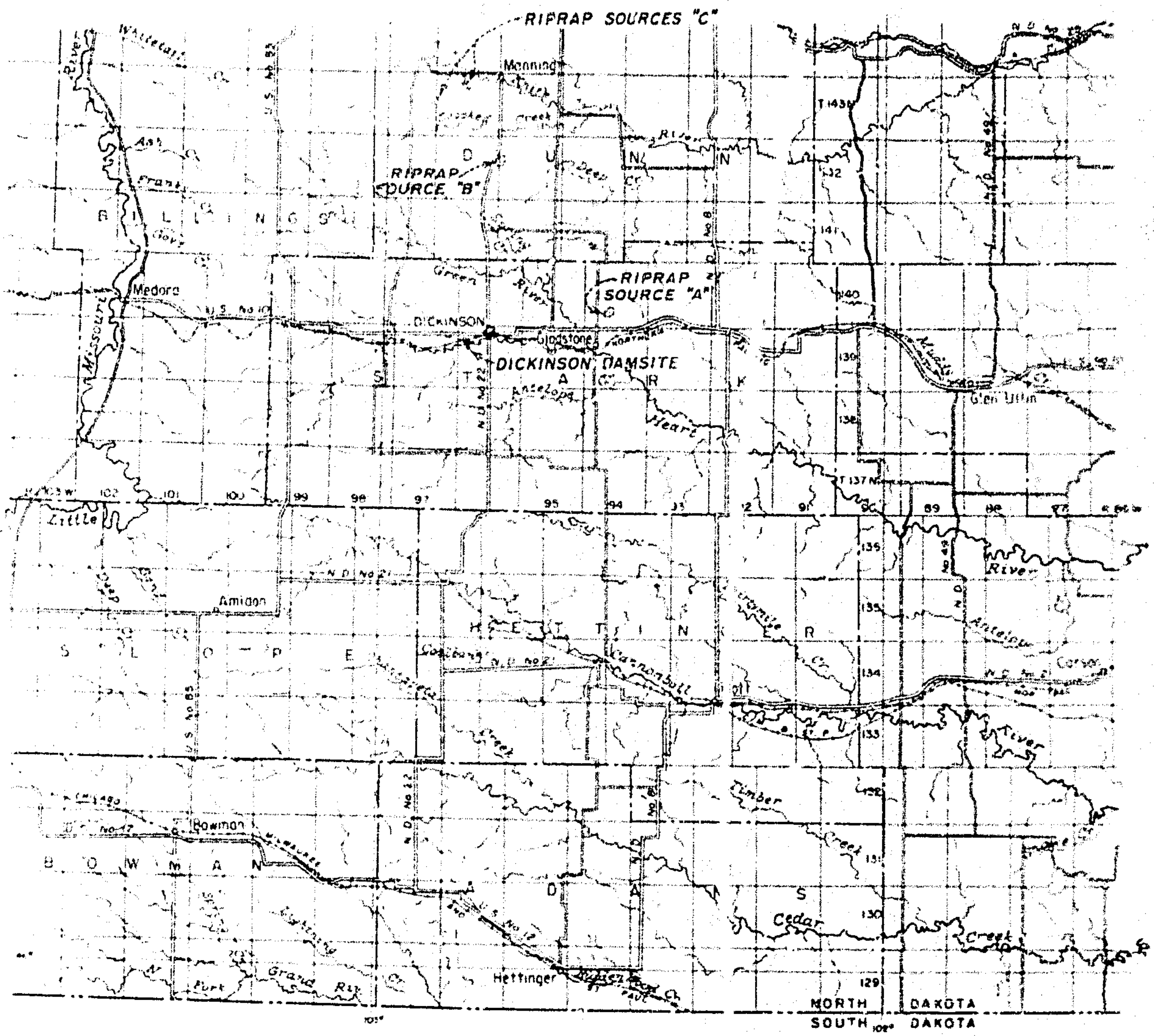
Flows through the stilling-basin of 10, 20, and 33.2 thousand second-feet, each with high and low tailwater, were observed. The hydraulic jump formed and appeared very much the same as that of the second design, as may be seen by comparing Figure 21 with Figures 24, 25, and 26. The character of the water surface is shown in the profiles of Figure 27.

Two-hour model scour tests were run with discharges of 10, 20 and 33.2 thousand second-feet, each with high and low tailwater. Negligible scouring occurred with discharges of 20,000 second-feet or less. For 33,200 second-feet the scour pattern showed that sand had moved upstream in the right-hand two-thirds of the downstream channel and was deposited close to the end sill. The deepest scour occurred on the left side well downstream from the end sill and away from the wing-wall. This erosion was not as deep as that found for the original design and will not endanger the prototype structure. The scour patterns for discharges of 33,200 second feet for both high and low tailwater are shown in Figure 28.

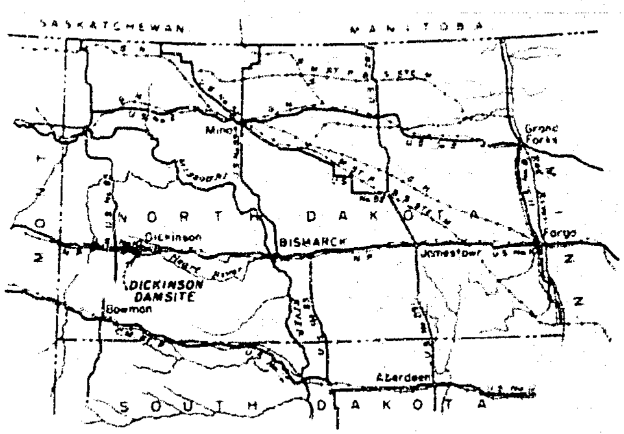
The stability of the hydraulic jump on the sloping apron was tested by setting the discharge at 33,200 second-feet and slowly lowering the tailwater elevation until the jump was swept from the apron. At tailwater elevation 2398.7 the jump had moved downstream sufficiently to wash out over the end sill in several places across the apron width. The tailwater elevation was then raised and at elevation 2398.8 the jump again fell back into the stilling-basin over the entire width. This latter elevation is 4.2 feet below the expected low tailwater elevation for a spillway discharge of 33,200 second-feet.

A comparison of Figures 28 and 18 and an analysis of the tests performed indicates that the improvement of the scour pattern is due to replacing the 90° wing-walls with 45° walls, since sloping the apron should not in itself improve the scour pattern. To determine the exact effect of the 45° walls, a scour test, Figure 29, with low tailwater and the spillway passing 33,200 second-feet was made on the recommended design just described, using 90° wing-walls instead of the 45° walls. The scour pattern was almost identical to that of the original design, Figure 18, indicating that the improved scour pattern of the recommended design was due entirely to the 45° wing-walls. The lesser amount of scour below the left-hand side of the pool is the result of replacing the 90° wing-wall with a 45° wing-wall. The improvement resulted because the 45° wall extended out into the pool, preventing some of the underwater eddy current from sweeping in from the side and scouring the pool bottom.

FIGURE 1



LOCATION MAP



INDEX MAP

10 0 10 20 30

SCALE OF MILES

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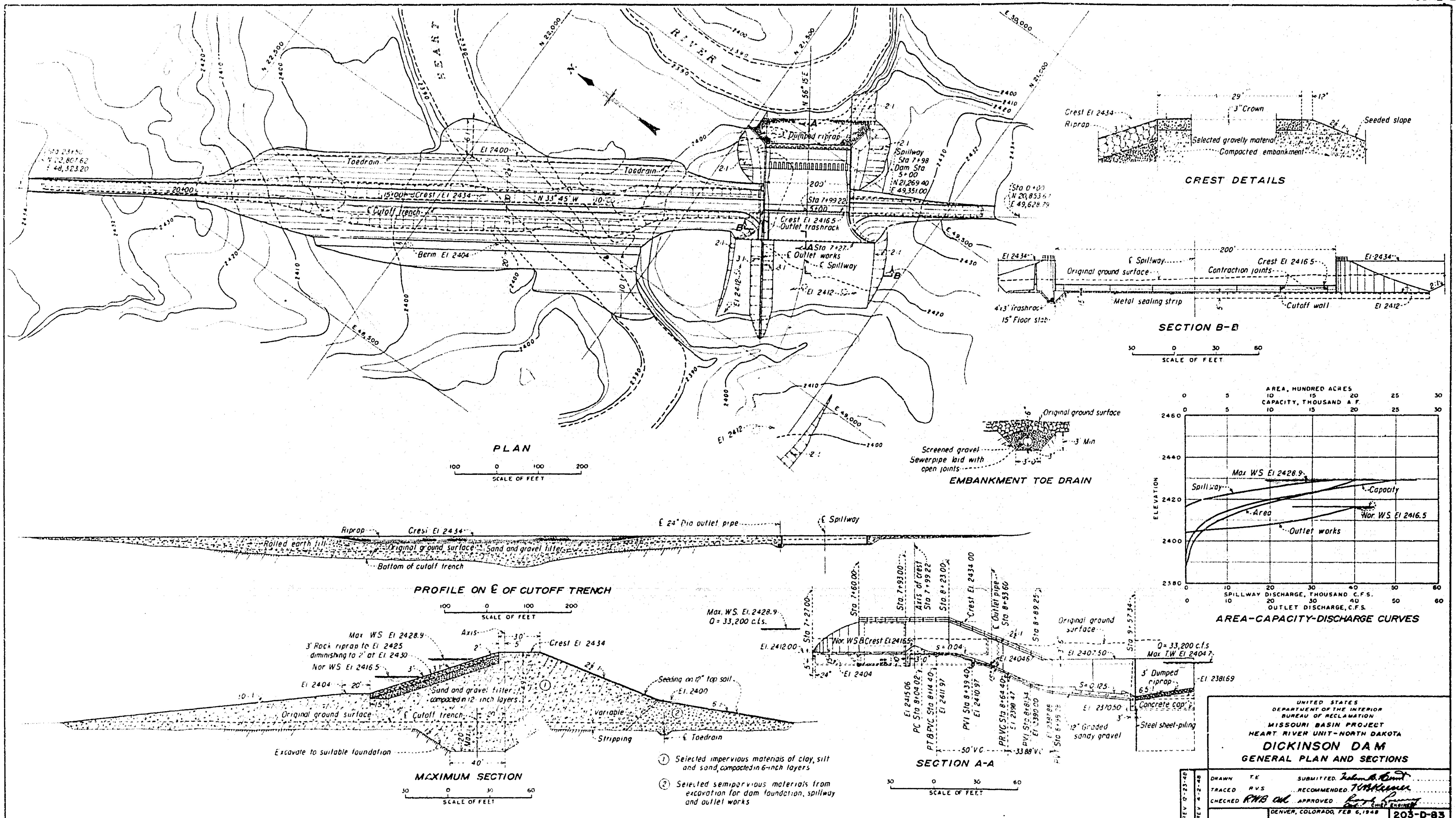
MISSOURI BASIN PROJECT
HEART RIVER UNIT - NORTH DAKOTA

DICKINSON DAM
LOCATION MAP

DRAWN: ...... SUBMITTED: ......
TRACED: ...... RECOMMENDED: ......
CHECKED: ...... APPROVED: ......

DENVER, COLORADO - JAN. 22, 47 | 203-D-40


PLAN
CREST DETAILS
SECTION B-B
EMBANKMENT TOE DRAIN
AREA-CAPACITY-DISCHARGE CURVES
PROFILE ON ℄ OF CUTOFF TRENCH
MAXIMUM SECTION
SECTION A-A
Crest El 2434
Riprap
Selected gravelly material
Compacted embankment
Seeded slope
3" Crown
Toedrain
Cutoff trench
Berm El 2404
Spillway
Outlet works
Outlet trashrack
Dumped riprap
Original ground surface
Metal sealing strip
Contraction joints
Cutoff wall
Screened gravel
Sewerpipe laid with open joints
Max WS El 2428.9
Nor WS El 2416.5
Capacity
Area
Rolled earth fill
Sand and gravel filter
Bottom of cutoff trench
3' Rock riprap to El 2425 diminishing to 2' at El 2430
Sand and gravel filter compacted in 12 inch layers
Excavate to suitable foundation
Seeding on 12" top soil
Stripping
Toedrain
Q = 33,200 c.f.s.
Concrete cap
Steel sheet-piling
12" Graded sandy gravel
SCALE OF FEET
Selected impervious materials of clay, silt and sand, compacted in 6-inch layers
Selected semipervious materials from excavation for dam foundation, spillway and outlet works
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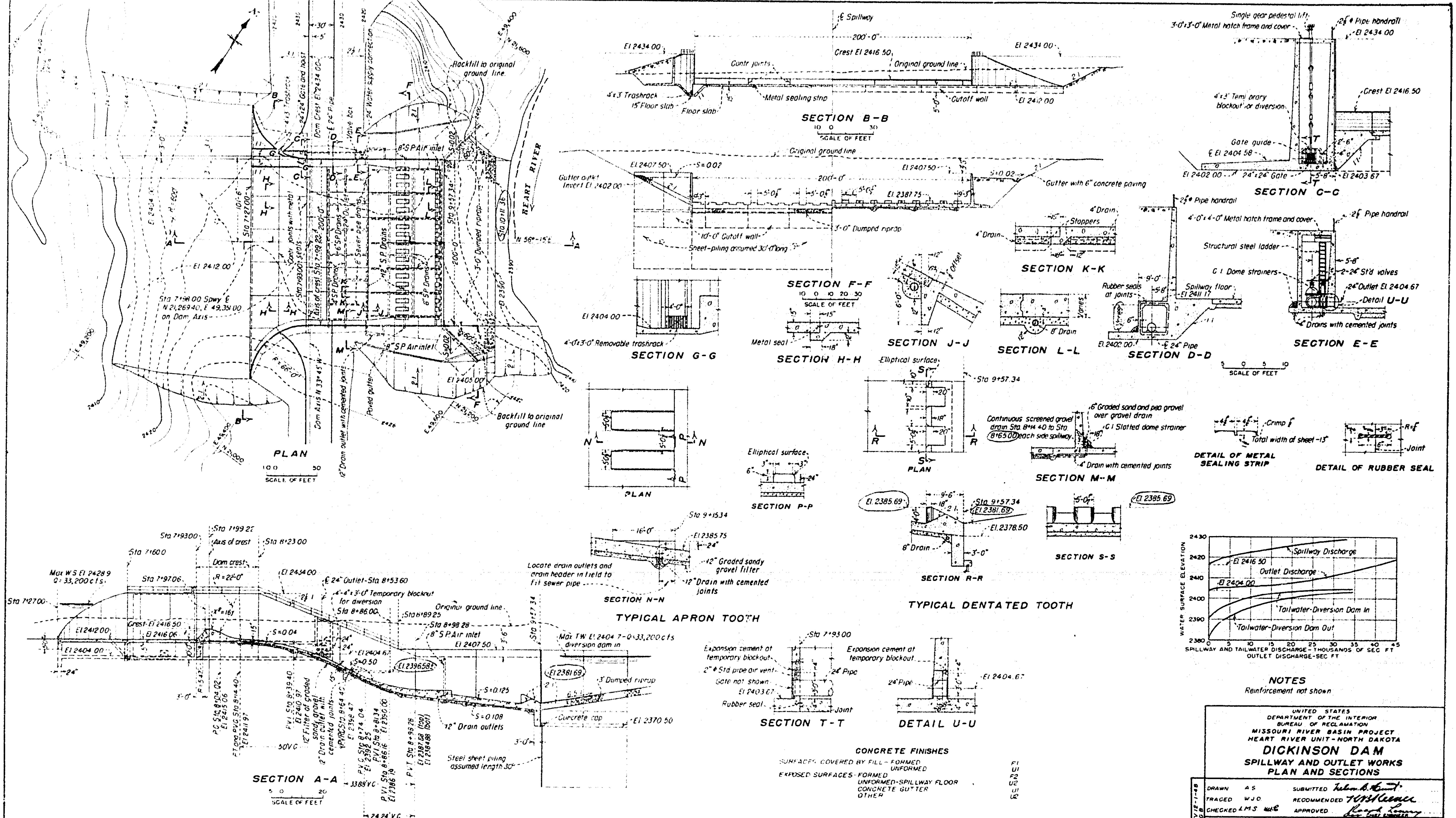
MISSOURI BASIN PROJECT
HEART RIVER UNIT-NORTH DAKOTA
DICKINSON DAM
GENERAL PLAN AND SECTIONS
DENVER, COLORADO, FEB 6, 1948
203-D-83

FIGURE 3



PLAN
SCALE OF FEET
HEART RIVER
Backfill to original ground line
8" S.P. Air inlet
Sta 7+98.00 Spwy ℄
N 21,269.40, E 49,351.00
on Dam Axis
El 2412.00
Dam Axis N 33°45' W
12" Drain outlet with cemented joints
Paved gutter
El 2405.00
Sta 10+11.36
5'-0" Dumped riprap
SECTION B-B
El 2434.00
200'-0"
℄ Spillway
Crest El 2416.50
Contr joints
Original ground line
4'x3' Trashrack
15" Floor slab
Floor slab
Metal sealing strip
Cutoff wall
El 2412.00
SECTION F-F
Original ground line
El 2407.50
S=0.02
Gutter outlet Invert El 2402.00
Gutter with 6" concrete paving
El 2387.75
10'-0" Cutoff wall
Sheet-piling assumed 30'-0" long
3'-0" Dumped riprap
SECTION C-C
Single gear pedestal lift
3'-0"x3'-0" Metal hatch frame and cover
2½" ϕ Pipe handrail
El 2434.00
Crest El 2416.50
4'x3' Temporary blockout for diversion
Gate guide
℄ El 2404.58
El 2402.00
24"x24" Gate
El 2403.67
SECTION G-G
El 2404.00
4'-0"x3'-0" Removable trashrack
SECTION H-H
Metal seal
SECTION J-J
Offset
SECTION K-K
4" Drain
Stoppers
SECTION L-L
8" Drain
Varies
SECTION D-D
Rubber seals at joints
Spillway floor
El 2411.17
El 2402.00
℄ 24" Pipe
SECTION E-E
4'-0"x4'-0" Metal hatch frame and cover
2½" Pipe handrail
Structural steel ladder
C.I. Dome strainers
2-24" Std valves
24" Outlet El 2404.67
Detail U-U
4" Drains with cemented joints
SCALE OF FEET
PLAN
SECTION P-P
Elliptical surface
SECTION N-N
Sta 9+15.34
El 2385.75
12" Graded sandy gravel filter
12" Drain with cemented joints
Locate drain outlets and drain header in field to fit sewer pipe
TYPICAL APRON TOOTH
PLAN
Sta 9+57.34
SECTION R-R
El 2385.69
El 2381.69
El 2378.50
8" Drain
SECTION S-S
TYPICAL DENTATED TOOTH
SECTION M-M
6" Graded sand and pea gravel over gravel drain
Continuous screened gravel drain Sta 8+14.40 to Sta 8+65.00 each side spillway
C.I. Slotted dome strainer
4" Drain with cemented joints
DETAIL OF METAL SEALING STRIP
Crimp ℄
Total width of sheet - 15"
DETAIL OF RUBBER SEAL
Joint
SPILLWAY AND TAILWATER DISCHARGE - THOUSANDS OF SEC FT
OUTLET DISCHARGE - SEC FT
WATER SURFACE ELEVATION
Spillway Discharge
El 2416.50
Outlet Discharge
El 2404.00
Tailwater-Diversion Dam In
Tailwater-Diversion Dam Out
SECTION A-A
Max W.S. El 2428.9
Q = 33,200 c.f.s.
Sta 7+27.00
Sta 7+60.0
Sta 7+93.00
Sta 7+97.06
Sta 7+99.22
Axis of crest
Sta 8+23.00
Dam crest
El 2434.00
℄ 24" Outlet - Sta 8+53.60
4'-4"x3'-0" Temporary blockout for diversion
Sta 8+86.00
Original ground line
Sta 8+98.28
8" S.P. Air inlet
El 2407.50
Max T.W. El 2404.7 - Q = 33,200 c.f.s. diversion dam in
El 2381.69
3' Dumped riprap
El 2396.58
S=0.125
S=0.108
12" Drain outlets
Concrete cap
El 2370.50
Steel sheet piling assumed length 30'
El 2412.00
El 2404.00
Crest El 2416.50
El 2416.06
S=0.04
S=0.50
SECTION T-T
Sta 7+93.00
Expansion cement at temporary blockout
2" ϕ Std pipe air vent
Gate not shown
El 2403.67
Rubber seal
24" Pipe
Joint
DETAIL U-U
24" Pipe
El 2404.67
CONCRETE FINISHES
SURFACES COVERED BY FILL - FORMED F1
UNFORMED U1
EXPOSED SURFACES - FORMED F2
UNFORMED - SPILLWAY FLOOR U2
CONCRETE GUTTER U1
OTHER U2
NOTES
Reinforcement not shown
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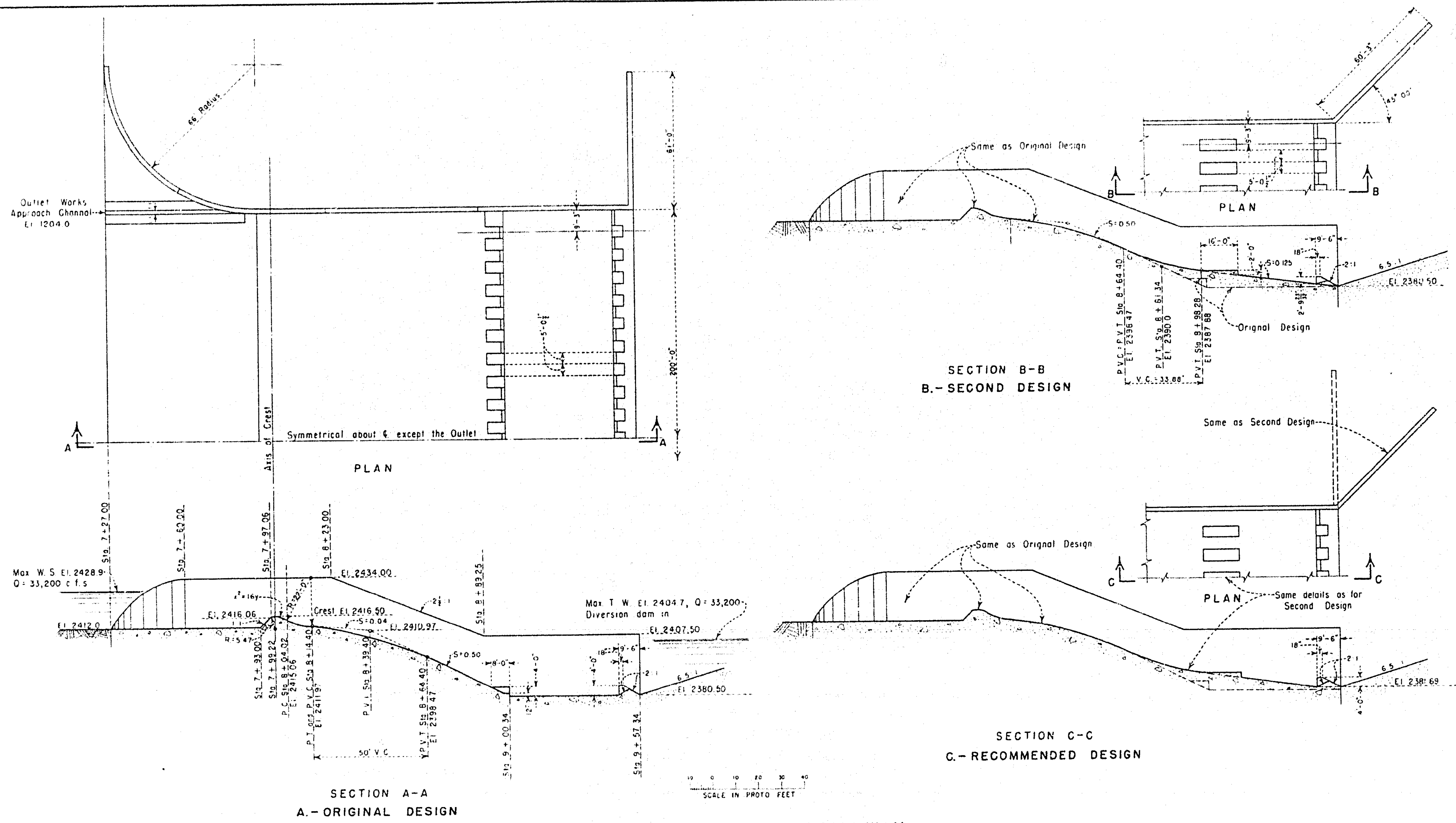
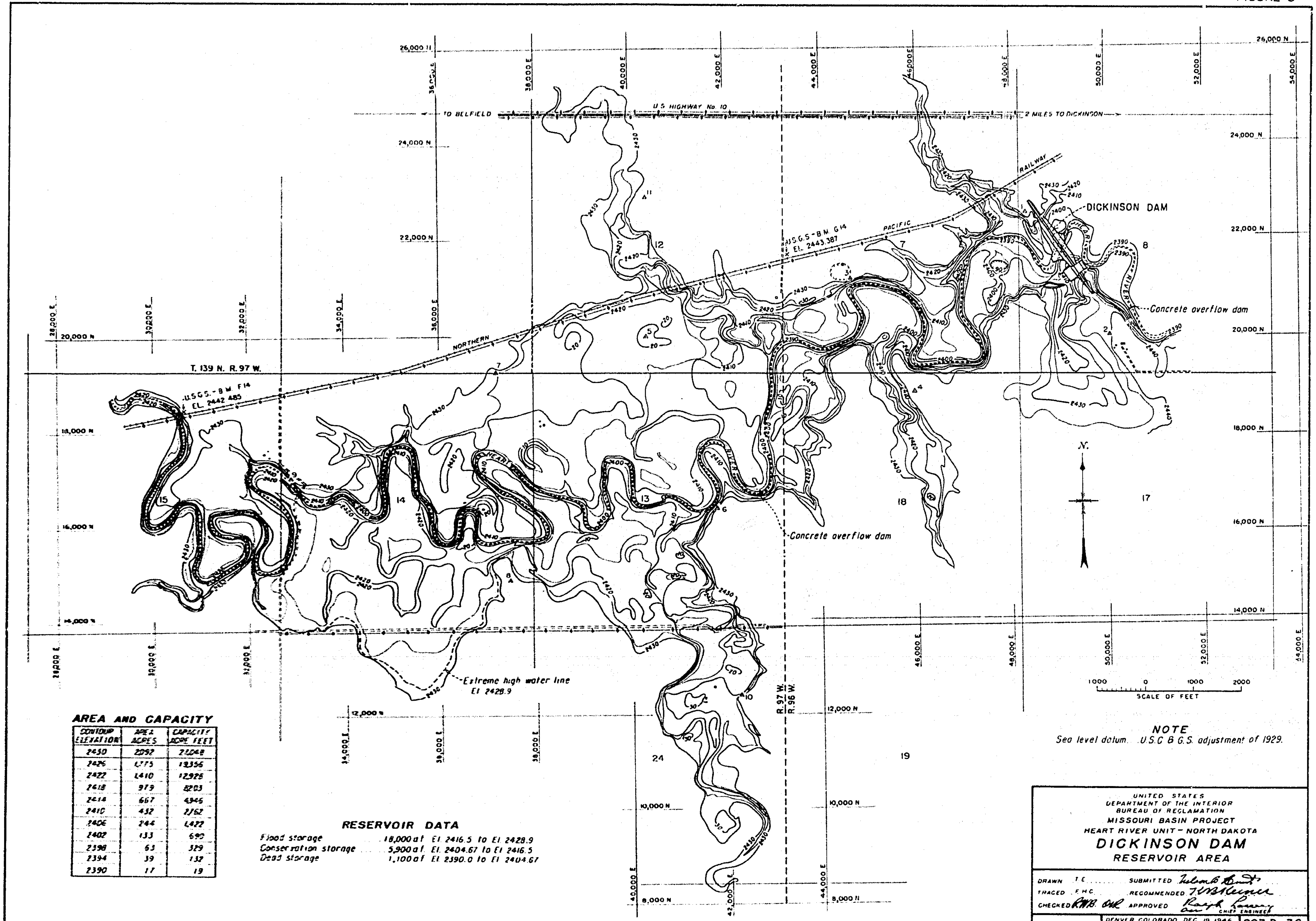
MISSOURI RIVER BASIN PROJECT
HEART RIVER UNIT - NORTH DAKOTA
DICKINSON DAM
SPILLWAY AND OUTLET WORKS
PLAN AND SECTIONS
DRAWN A.S.
TRACED W.J.O.
CHECKED L.M.S.
SUBMITTED
RECOMMENDED
APPROVED
DENVER, COLORADO, FEB. 6, 1948
203-D-84



DICKINSON DAM SPILLWAY

TEST DESIGNS

1:36 MODEL



AREA AND CAPACITY

CONTOUR ELEVATION	AREA ACRES	CAPACITY ACRE FEET
2430	2092	21048
2426	1775	19356
2422	1410	12925
2418	979	8203
2414	667	4946
2410	432	2762
2406	244	1422
2402	133	690
2398	63	329
2394	39	132
2390	17	19

RESERVOIR DATA

Flood storage	18,000 a.f.	El. 2416.5 to El. 2428.9
Conservation storage	5,900 a.f.	El. 2404.67 to El. 2416.5
Dead storage	1,100 a.f.	El. 2390.0 to El. 2404.67

NOTE
Sea level datum. U.S.C. & G.S. adjustment of 1929.

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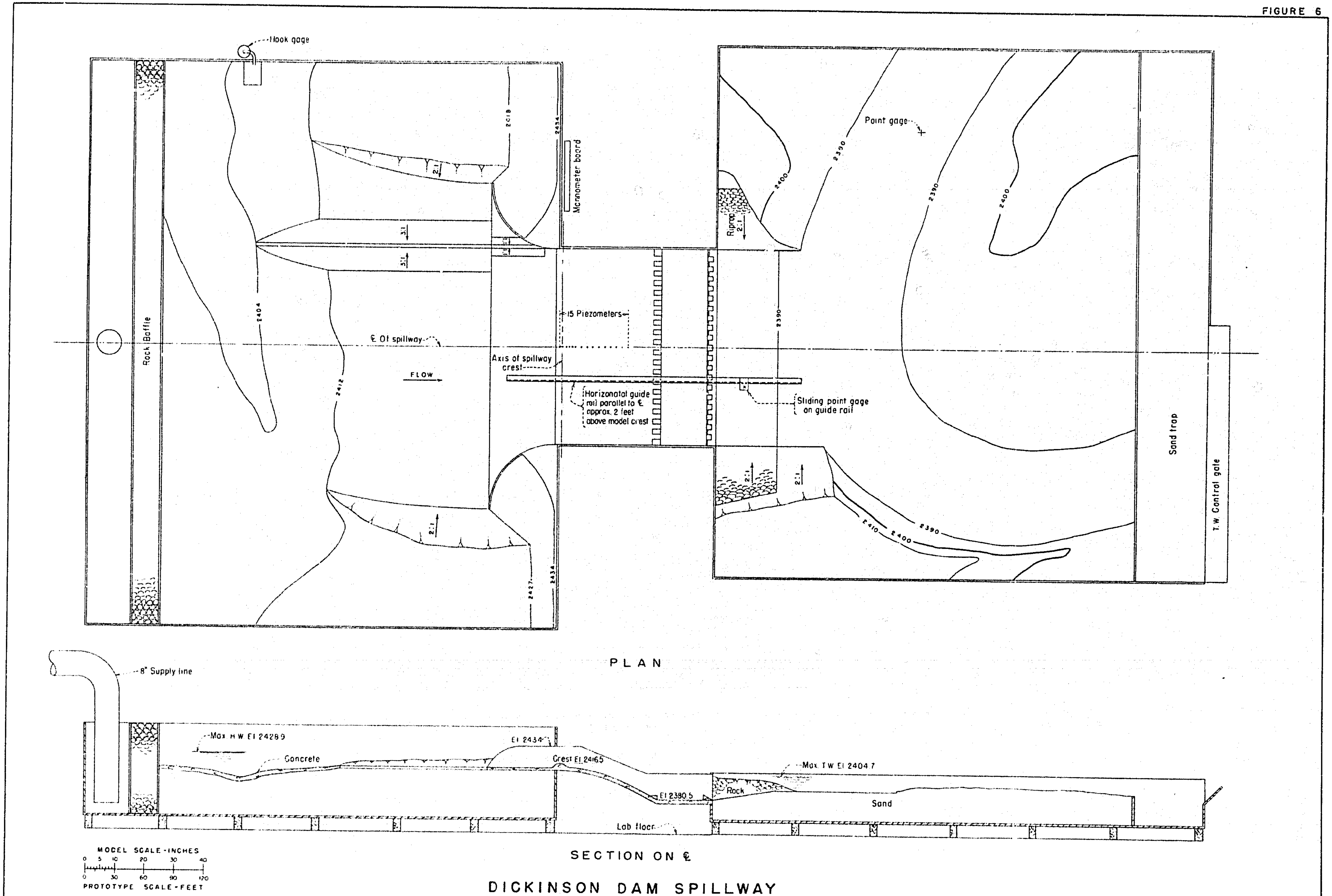
BUREAU OF RECLAMATION
MISSOURI BASIN PROJECT
HEART RIVER UNIT – NORTH DAKOTA

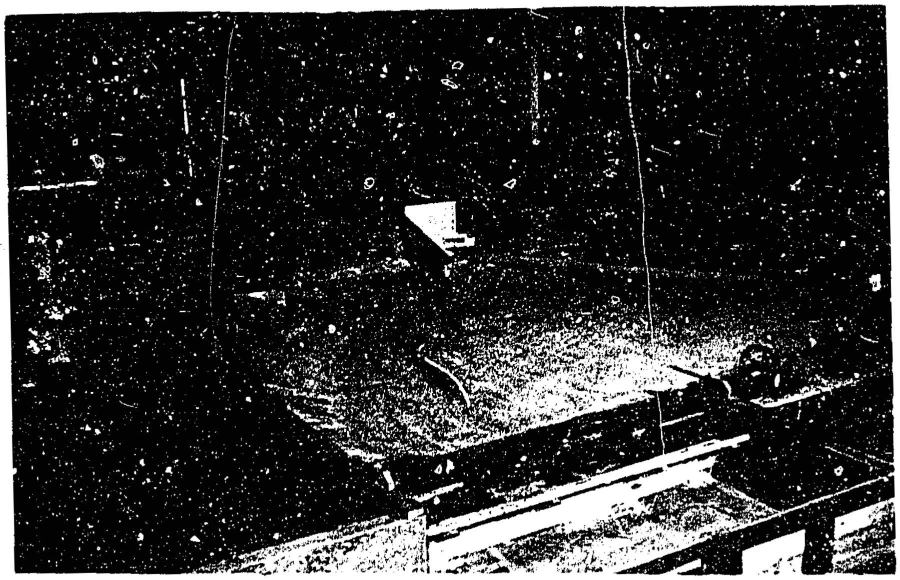
DICKINSON DAM
RESERVOIR AREA

DRAWN T.E. SUBMITTED
TRACED F.H.C. RECOMMENDED
CHECKED R.W.B. APPROVED
CHIEF ENGINEER

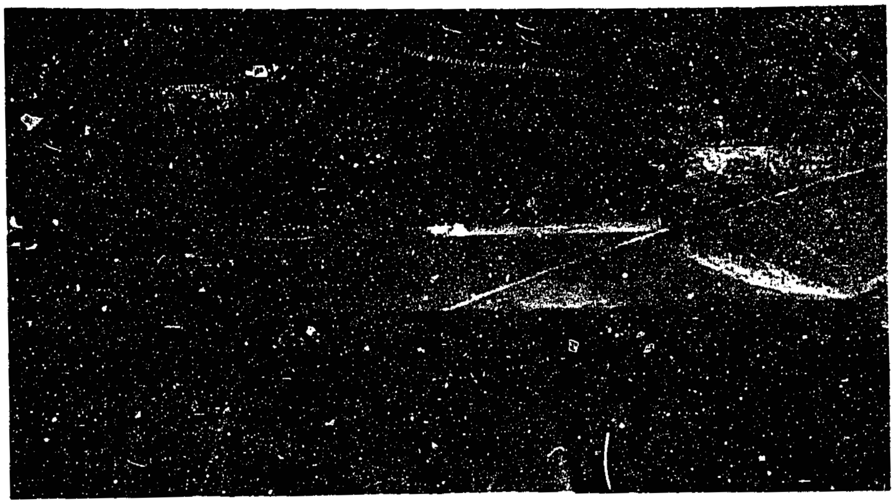
DENVER, COLORADO, DEC. 19, 1946 — 203-D-36



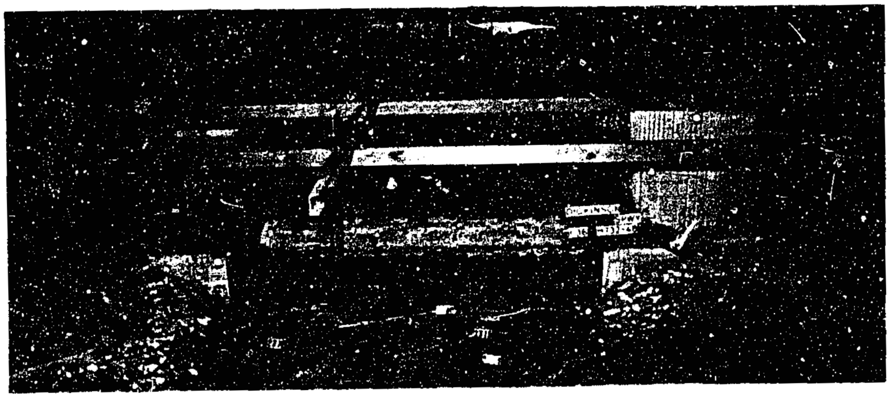
DICKINSON DAM SPILLWAY
MODEL LAYOUT - ORIGINAL DESIGN
1:36 MODEL



A. Looking upstream - Showing tailwater control gate, tailwater point gage, etc.

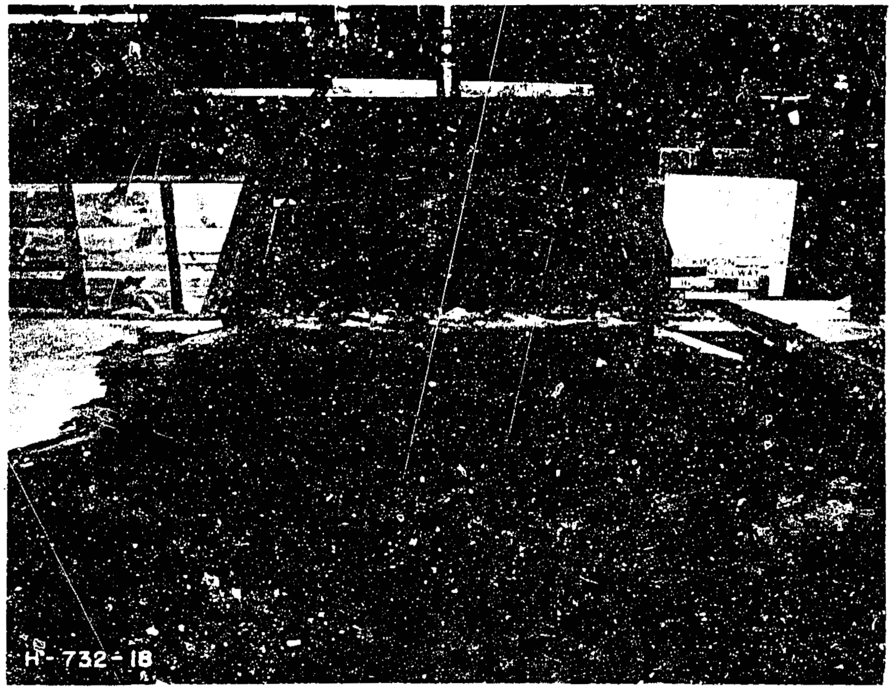


B. Looking downstream - Showing spillway approach

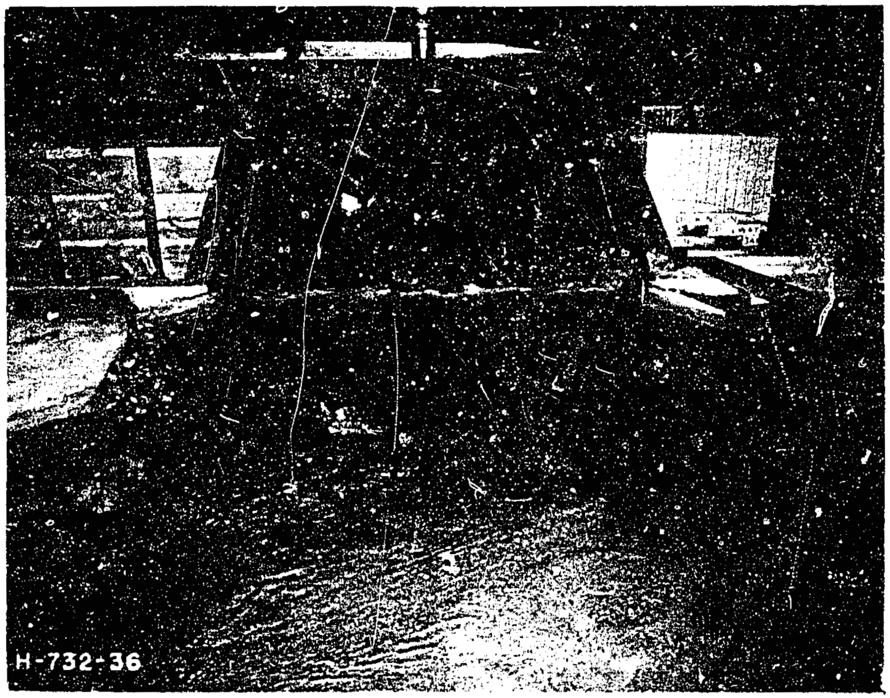


C. Looking upstream - Showing water-surface profile gage installed

DICKINSON DAM SPILLWAY
MODEL VIEWS - ORIGINAL DESIGN
1:36 MODEL

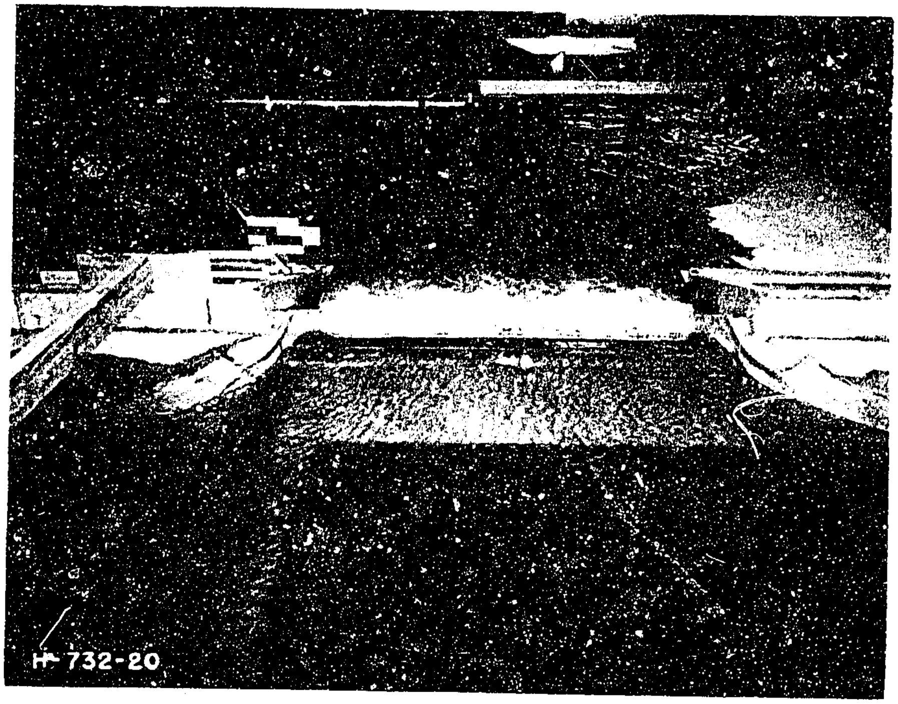


A. 33,200 second-feet - Low tailwater

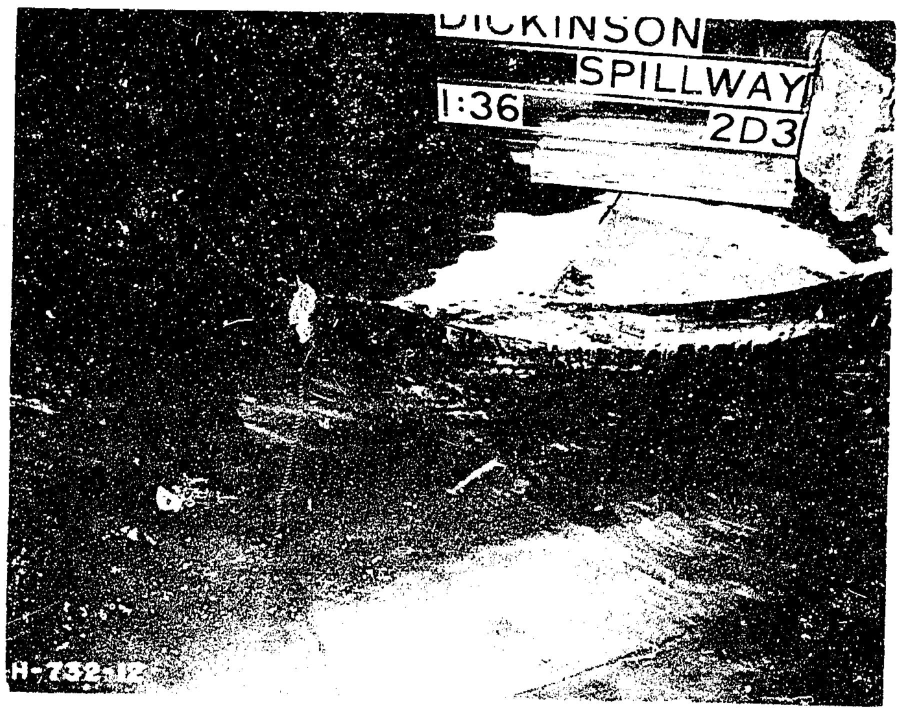


B. 10,000 second-feet - Low tailwater

DICKINSON DAM SPILLWAY
MODEL IN OPERATION - RECOMMENDED DESIGN
1:36 MODEL

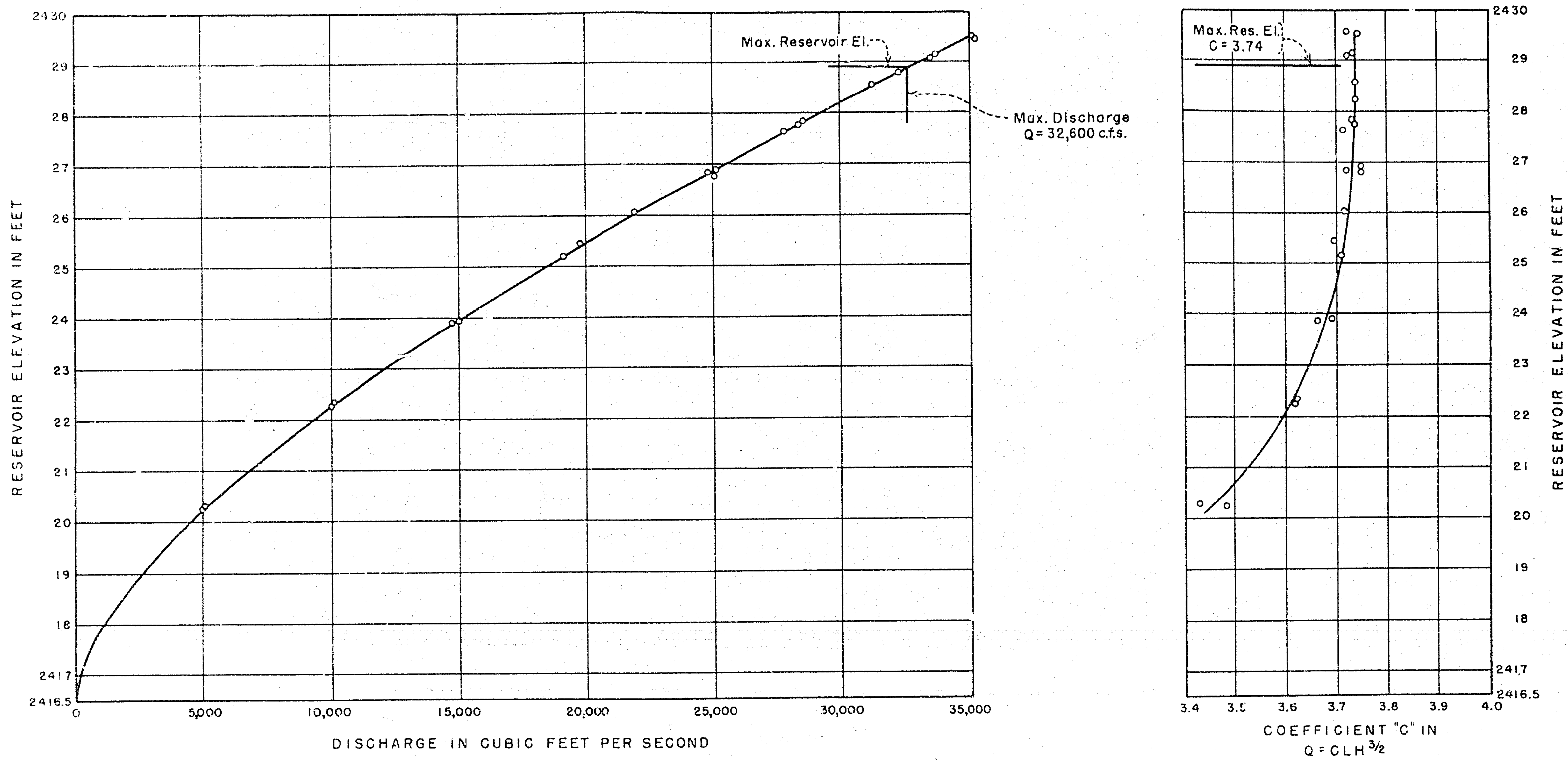


A. Flow in the spillway approach



B. Draw-down at left wing-wall

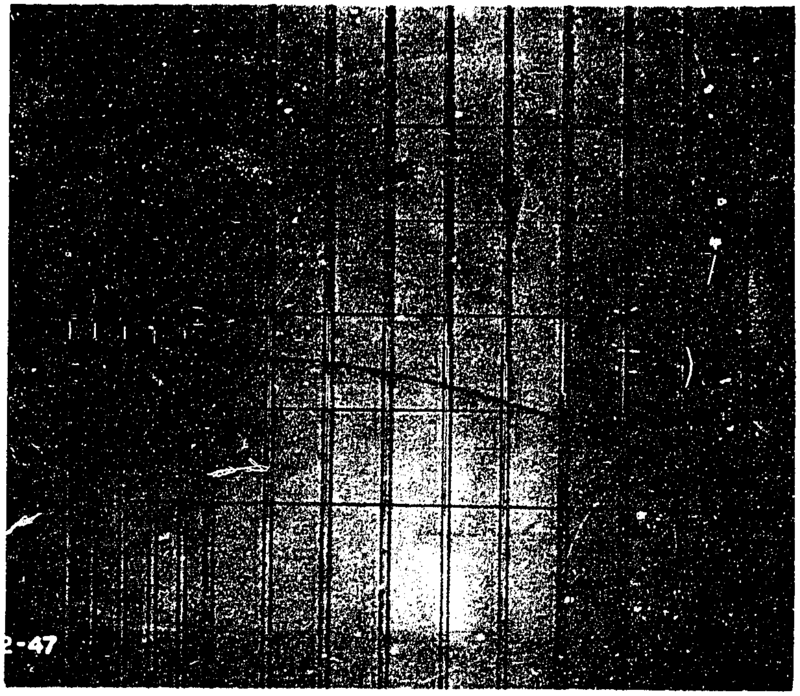
DICKINSON DAM SPILLWAY
SPILLWAY APPROACH - ORIGINAL AND RECOMMENDED DESIGN
DISCHARGE 33,200 SECOND-FEET
1:36 MODEL



DICKINSON DAM SPILLWAY

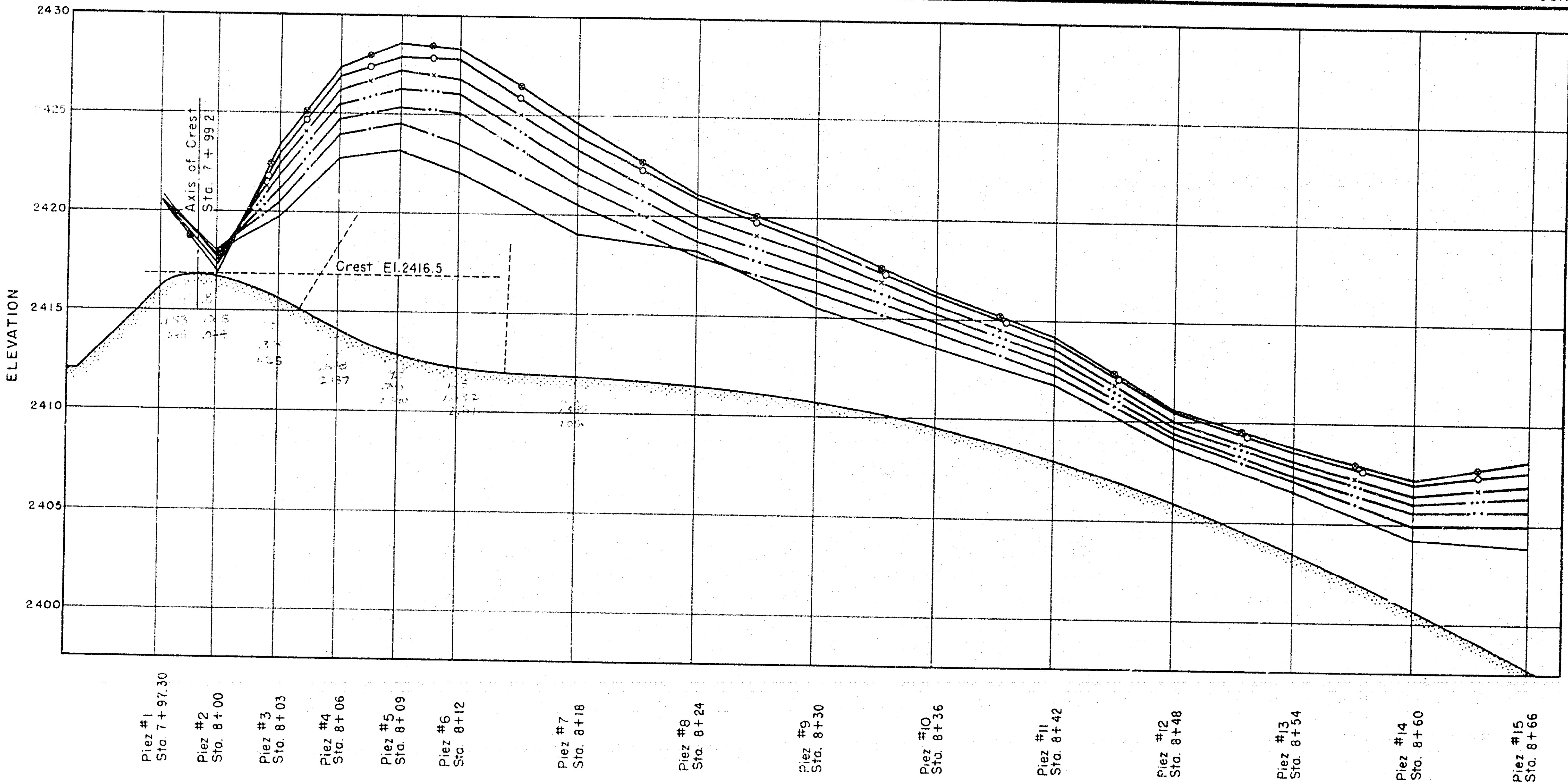
DISCHARGE AND COEFFICIENT OF DISCHARGE CURVES FOR THE ORIGINAL AND RECOMMENDED CREST DESIGN

1 : 36 MODEL



Manometor Board
Pressure scale is in feet of water, prototype

DICKINSON DAM SPILLWAY
SPILLWAY AND CREST PRESSURES FOR THE ORIGINAL AND RECOMMENDED DESIGN
DISCHARGE 33,200 SECOND-FEET
1:36 MODEL



SYMBOL	RESERVOIR ELEVATION	DISCHARGE C.F.S.	COEFFICIENT "C" IN $Q = CLH^{3/2}$
———	2428.62	31,560	3.74
—·—·—	2430.34	33,590	3.75
—··—··—	2431.67	44,090	3.73
—···—···—	2432.63	48,340	3.73
—×—	2433.64	52,910	3.73
—○—	2434.70	57,780	3.72
—⊗—	2435.69	63,080	3.75

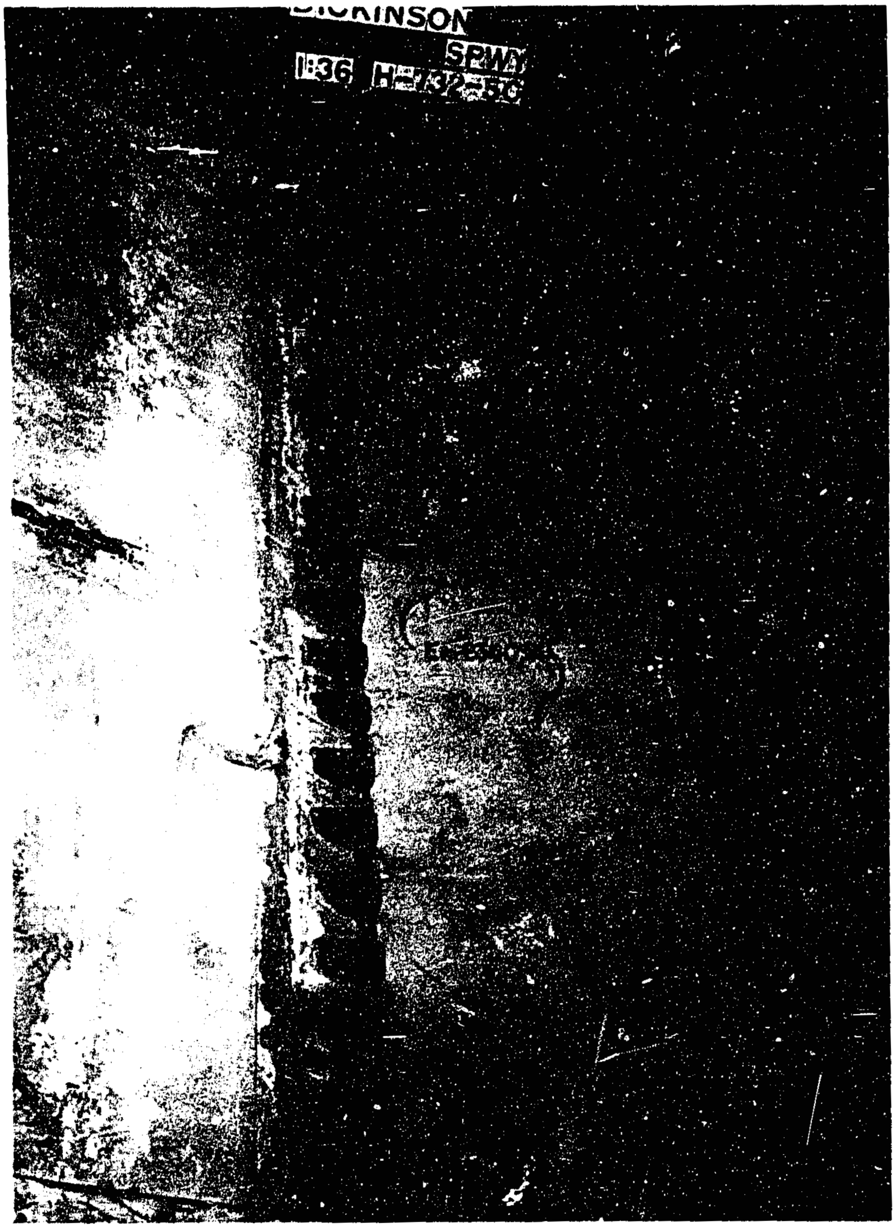
DICKINSON DAM SPILLWAY

SPILLWAY AND CREST PRESSURES
FOR THE ORIGINAL AND RECOMMENDED DESIGN

1:36 MODEL

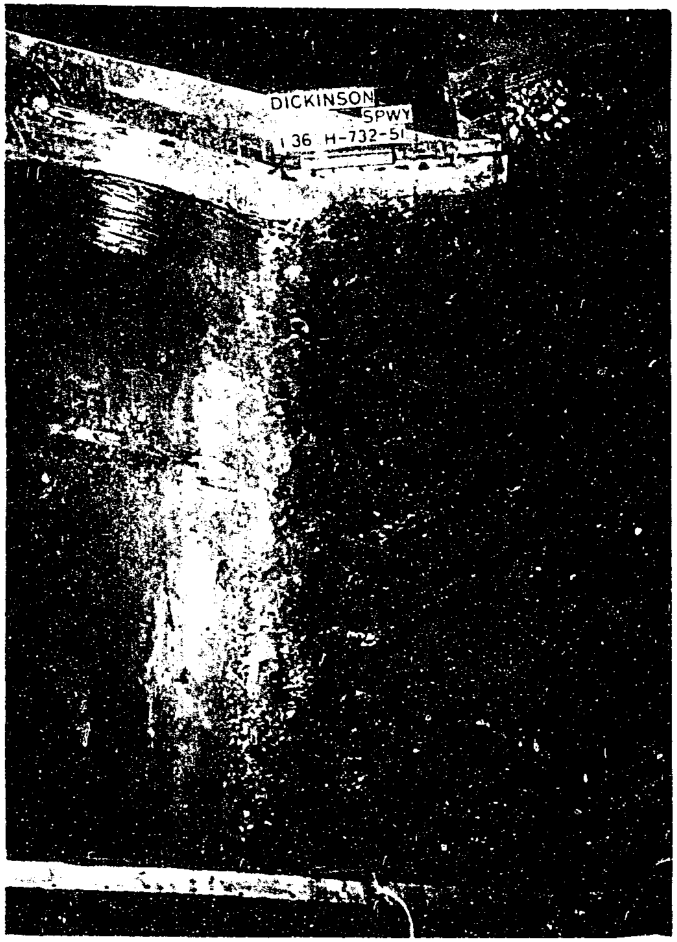
NOTE: Crest outline is the datum for zero pressure.

FIGURE 13

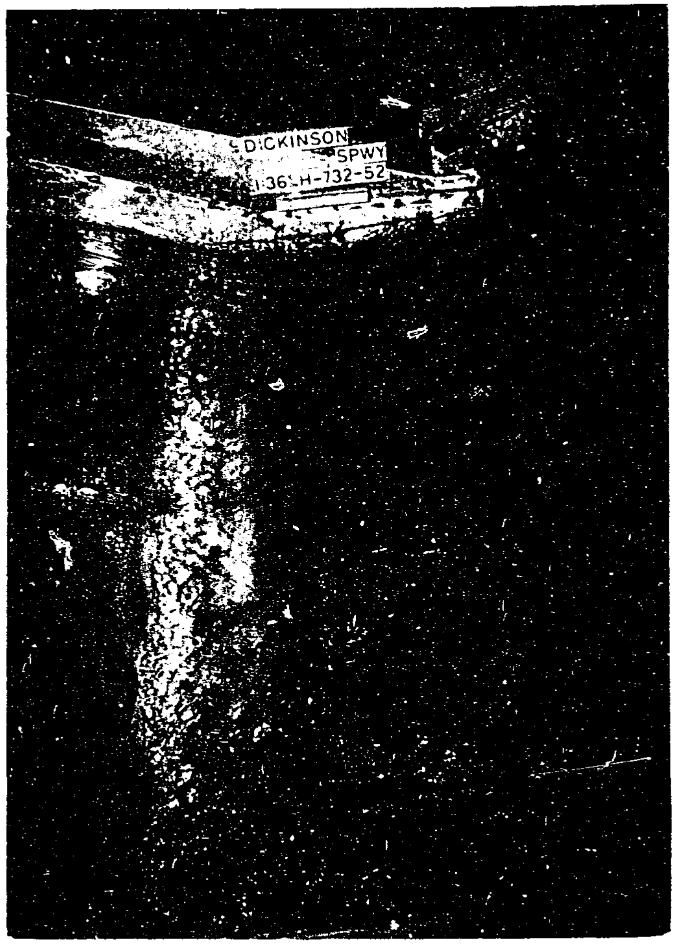


Stilling-basin with 90 degree wing-walls and dentils on end sill 4 feet high

DICKINSON DAM SPILLWAY
ORIGINAL STILLING-BASIN DESIGN - HORIZONTAL APRON
1:36 MODEL

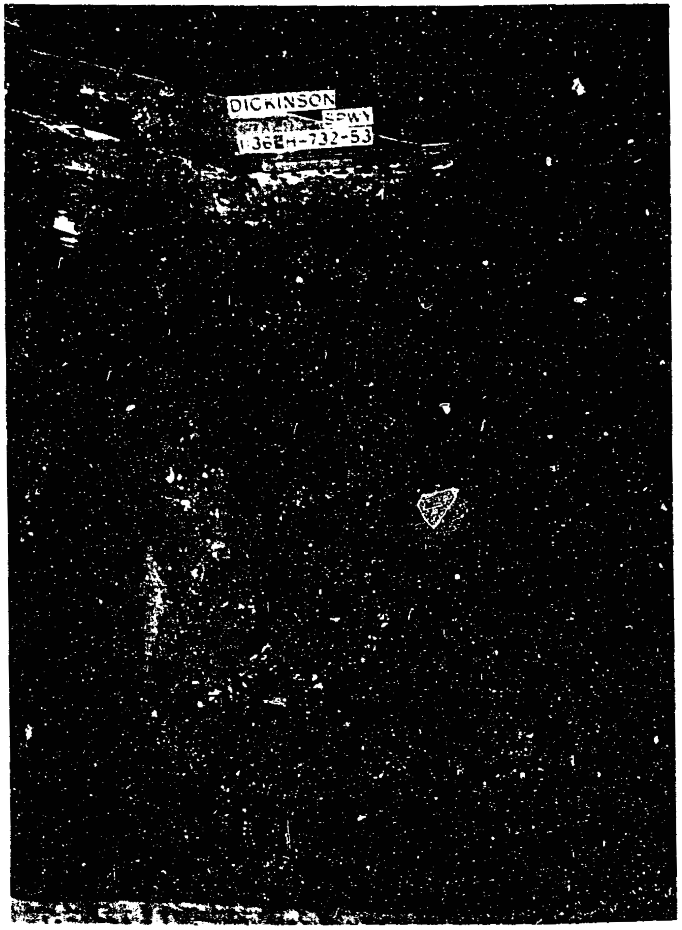


A. Low tailwater

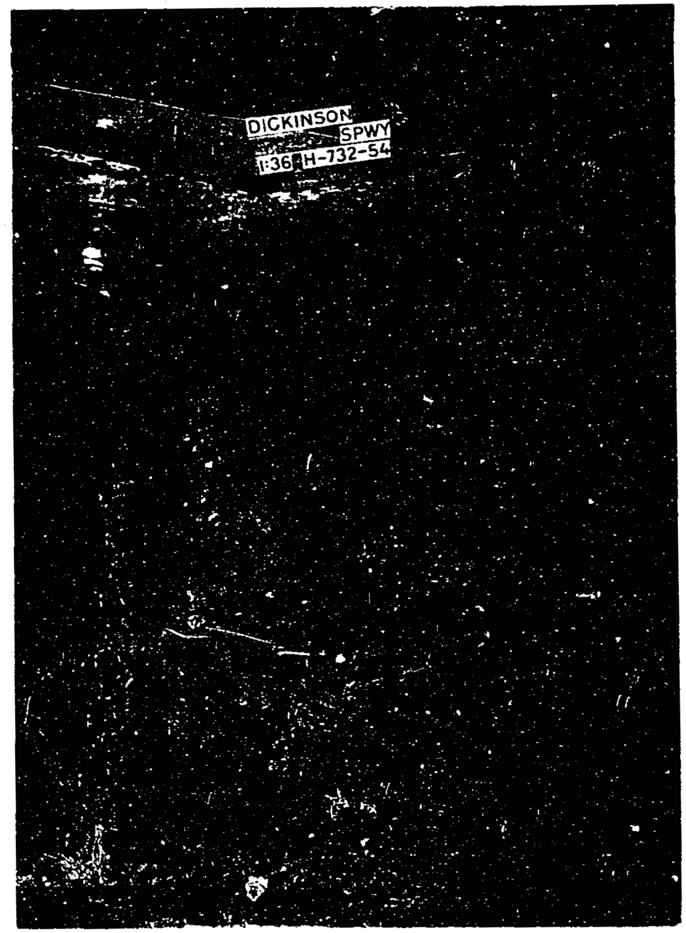


B. High tailwater

DICKINSON DAM SPILLWAY
ORIGINAL STILLING-BASIN DESIGN - HORIZONTAL APRON
DISCHARGE 10,000 SECOND-FEET
1:36 MODEL



A. Low tailwater



B. High tailwater

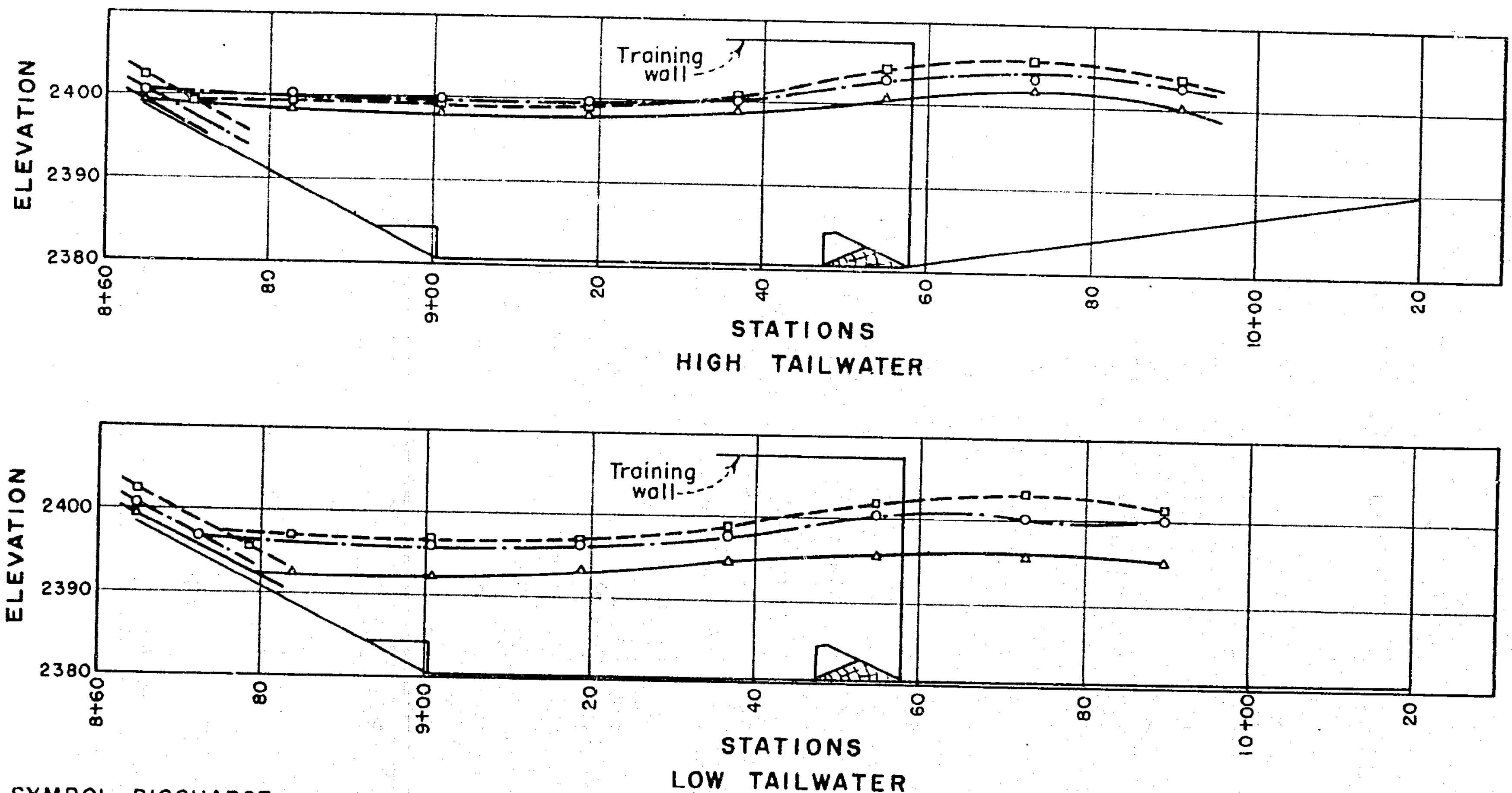
DICKINSON DAM SPILLWAY
ORIGINAL STILLING-BASIN DESIGN - HORIZONTAL APRON
DISCHARGE 20,000 SECOND-FEET
1:36 MODEL

FIGURE 15

A. Low tailwater

B. High tailwater

DICKINSON DAM SPILLWAY
ORIGINAL STILLING-BASIN DESIGN - HORIZONTAL APRON
DISCHARGE 33,200 SECOND-FEET
1:36 MODEL



SYMBOL-DISCHARGE

- 10,000 SEC.-FT.
- 20,000 SEC.-FT.
- 33,200 SEC.-FT.

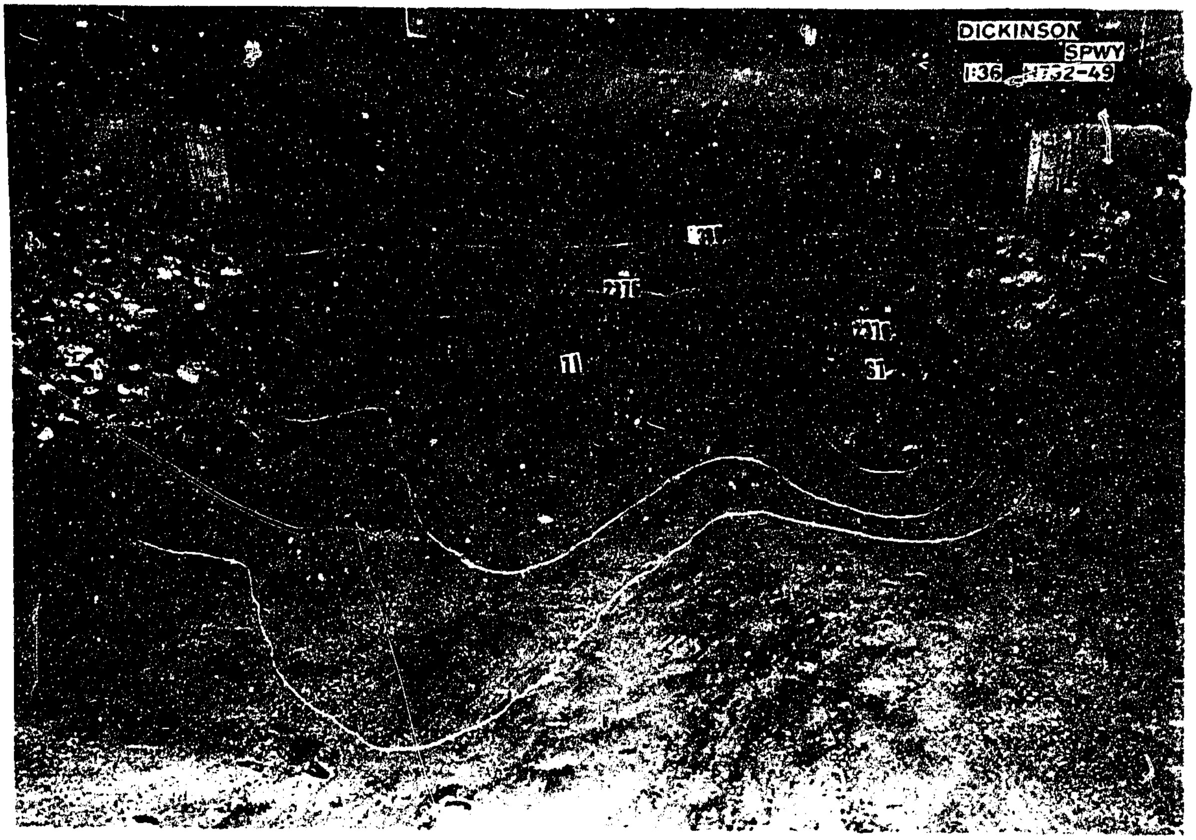
DICKINSON DAM SPILLWAY

WATER SURFACE PROFILES IN THE ORIGINAL STILLING BASIN DESIGN-HORIZONTAL APRON

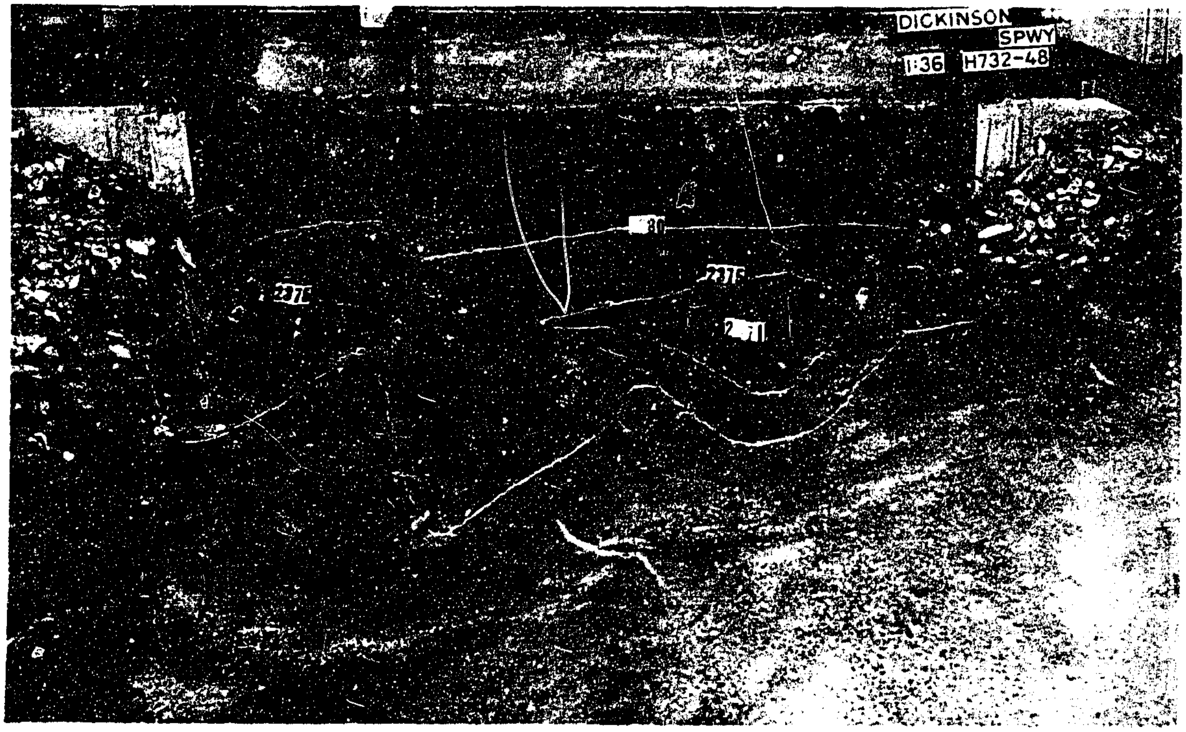
1:36 MODEL

FIGURE 17

FIGURE 18

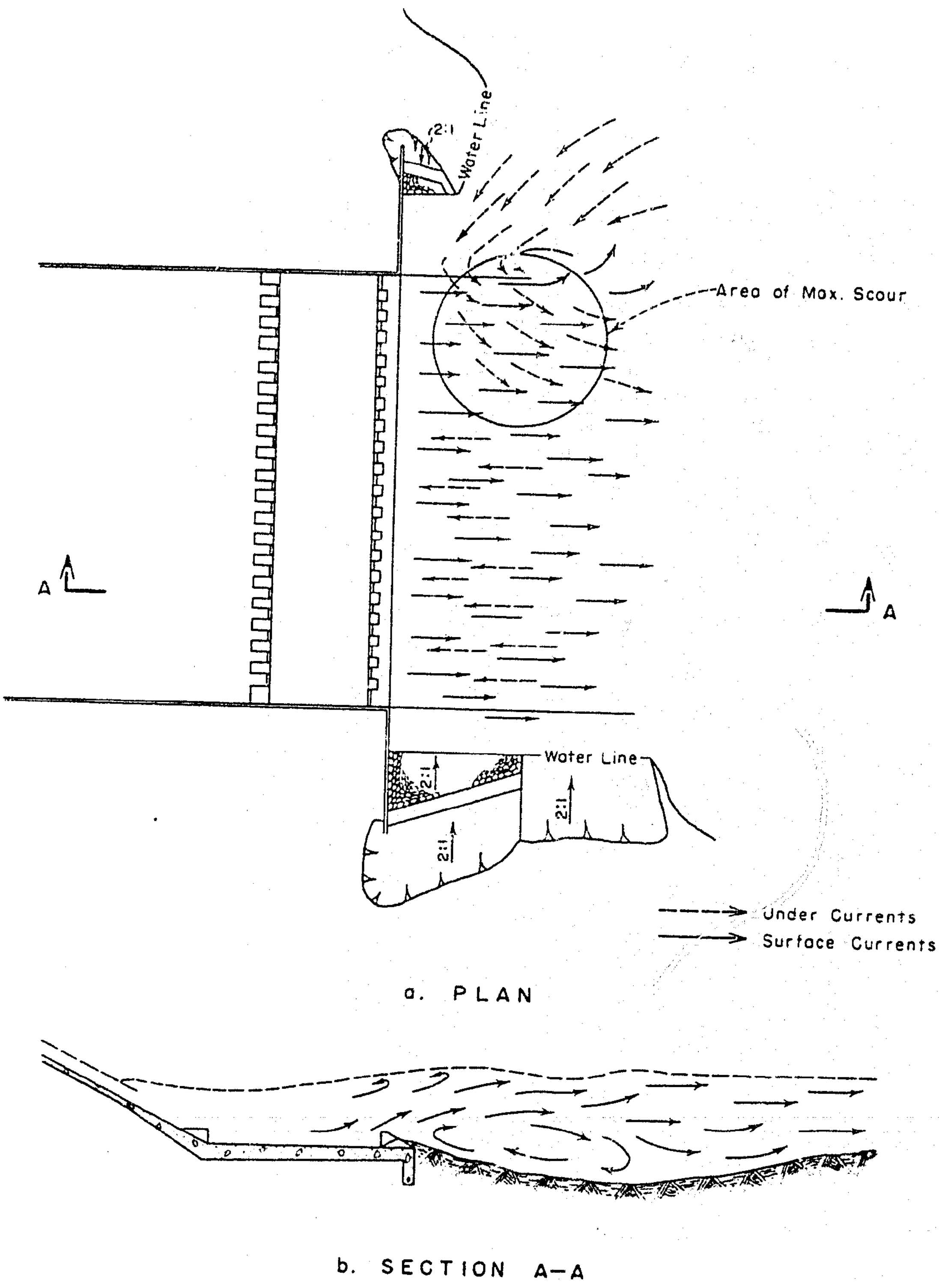


A. Erosion pattern after 2 hours operation of the model with low tailwater



B. Erosion pattern after 2 hours operation of the model with high tailwater

DICKINSON DAM SPILLWAY
ORIGINAL STILLING-BASIN DESIGN - HORIZONTAL APRON
SCOUR FOR 33,200 SECOND-FEET DISCHARGE
1:36 MODEL

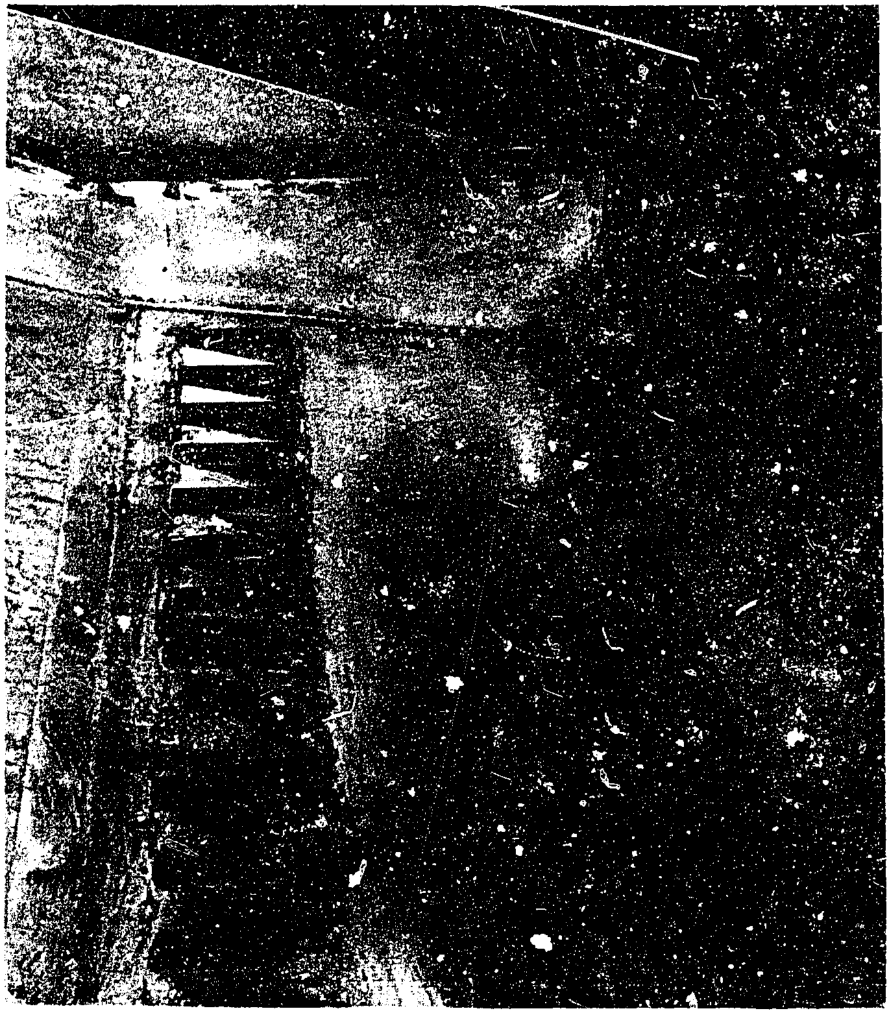


DICKINSON DAM SPILLWAY

FLOW CURRENTS IN THE ORIGINAL STILLING BASIN DESIGN—HORIZONTAL APRON

1:36 MODEL

FIGURE 20

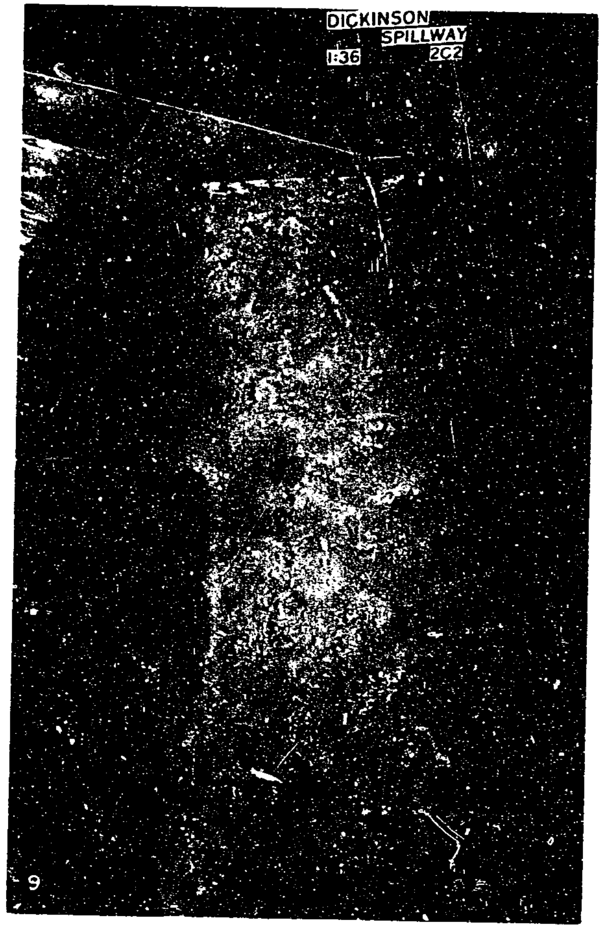


Stilling-basin with 45 degree wing-walls and dentils on end sill 2.81 feet high

DICKINSON DAM SPILLWAY
SECOND STILLING-BASIN DESIGN - SLOPING APRON
1:36 MODEL

FIGURE 21

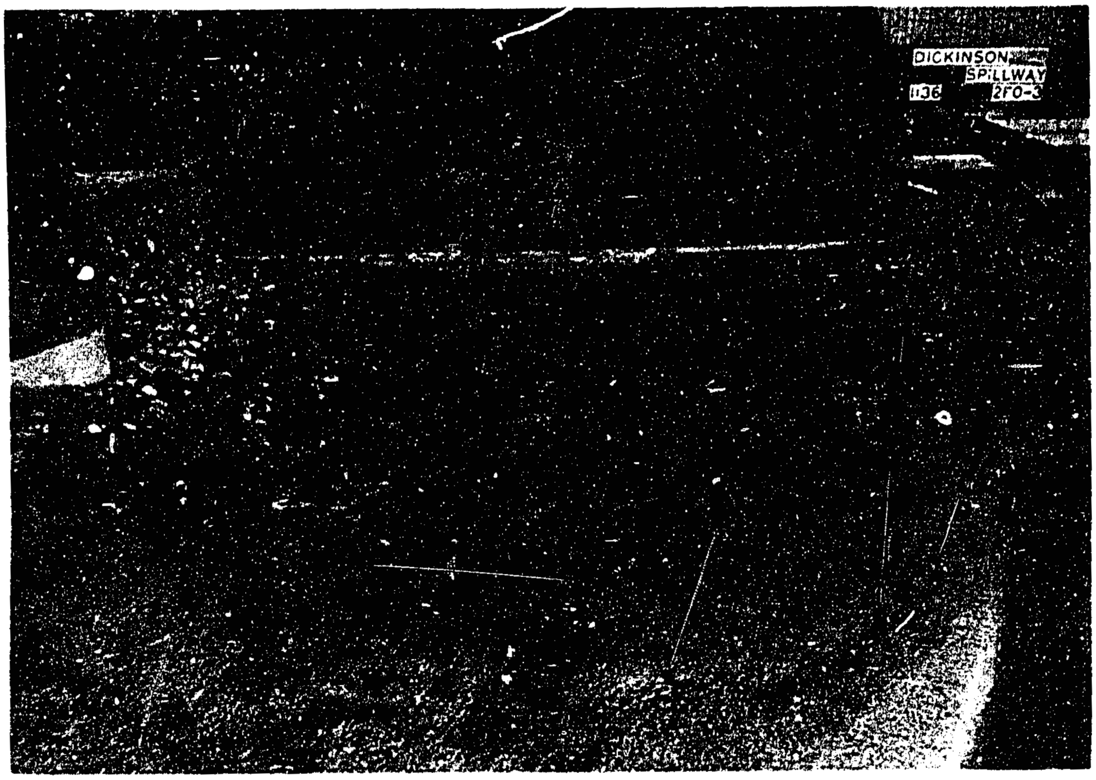
A. 10,000 second-feet
low tailwater



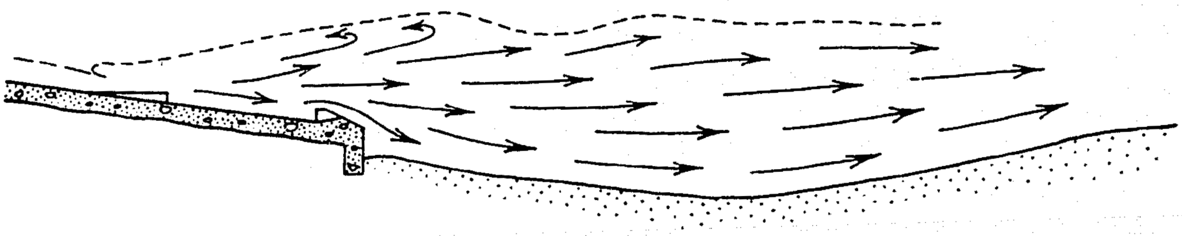
B. 20,000 second-feet
low tailwater

C. 33,200 second-feet
low tailwater

DICKINSON DAM SPILLWAY
SECOND STILLING-BASIN DESIGN IN OPERATION - SLOPING APRON
1:36 MODEL

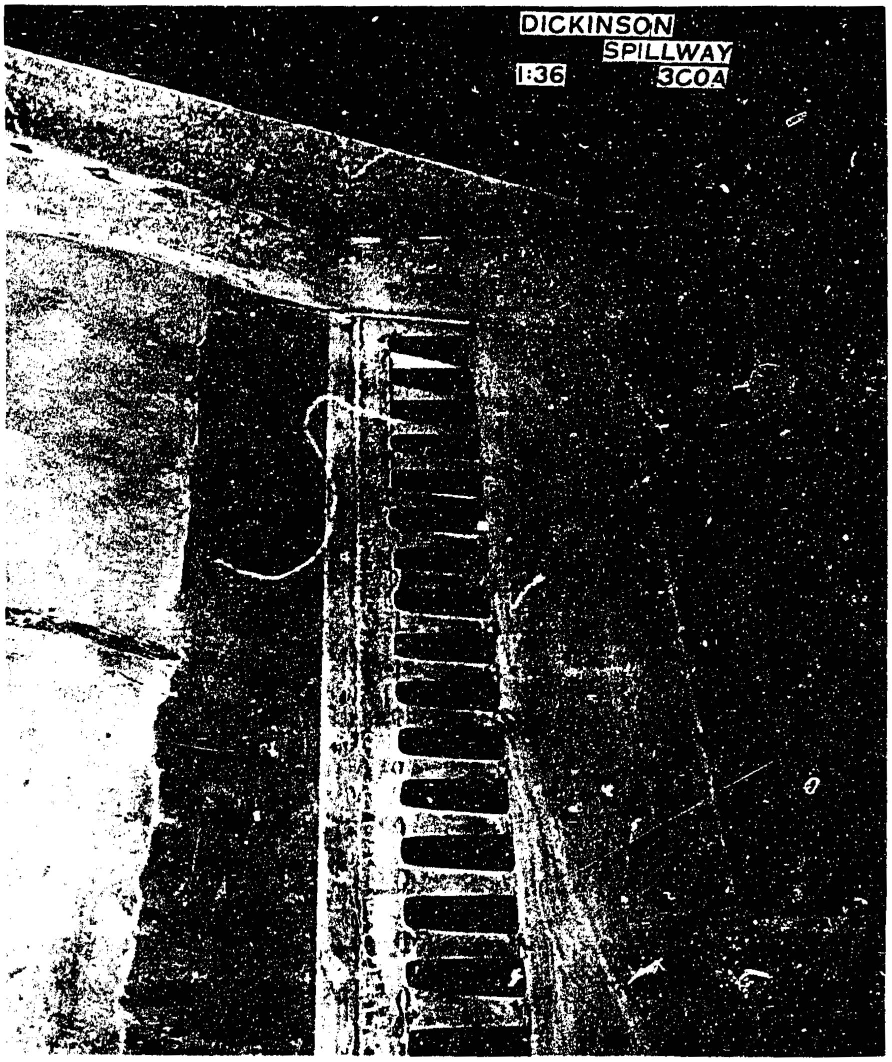


A. Scour resulting from 33,200 second-feet discharge model was operated 2 hours with low tailwater



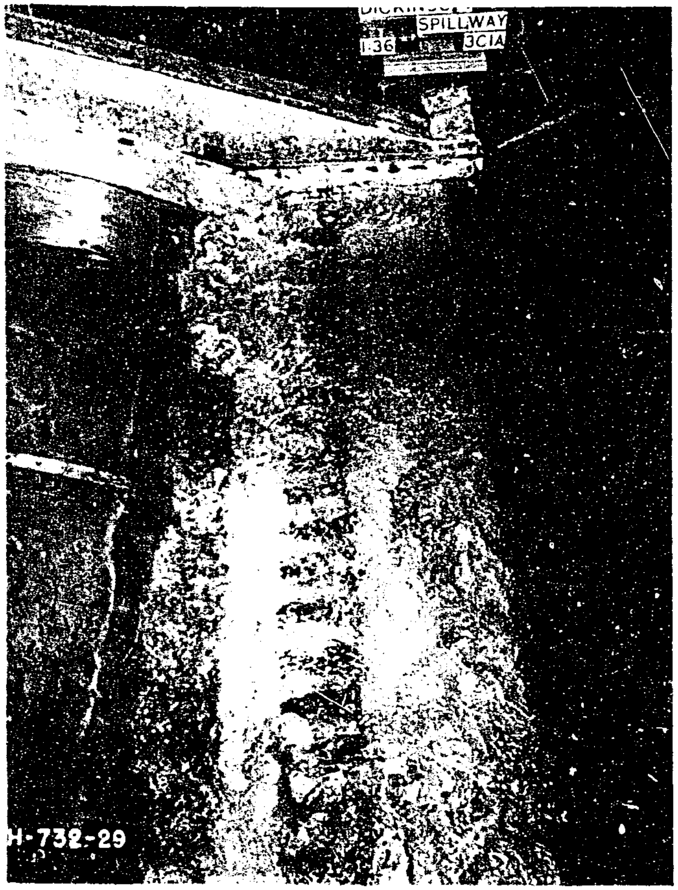
B. Flow currents

DICKINSON DAM SPILLWAY
SECOND STILLING-BASIN DESIGN - SLOPING APRON
SCCUR PATTERN AND FLOW CURRENTS
1:36 MODEL



Stilling-basin with 45 degree wing-walls and dentils on end sill 4 feet high

DICKINSON DAM SPILLWAY
RECOMMENDED STILLING-BASIN DESIGN - SLOPING APRON
1:36 MODEL



A. High tailwater

B. Low tailwater

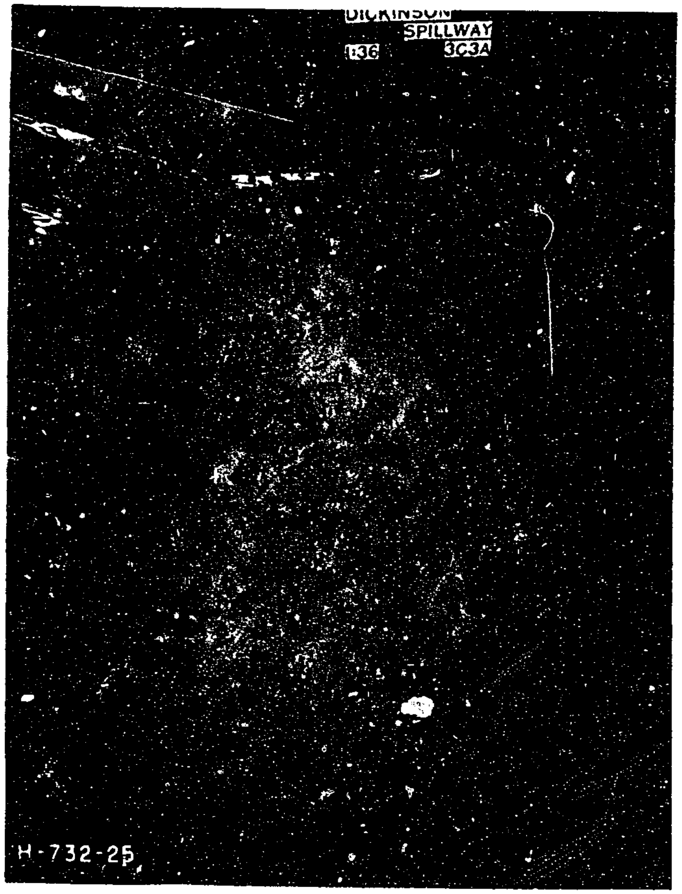
DICKINSON DAM SPILLWAY
RECOMMENDED STILLING-BASIN DESIGN - SLOPING APRON
DISCHARGE 10,000 SECOND-FEET
1:36 MODEL

A. High tailwater

B. Low tailwater

DICKINSON DAM SPILLWAY
RECOMMENDED STILLING-BASIN DESIGN - SLOPING APRON
DISCHARGE 20,000 SECOND-FEET
1:36 MODEL

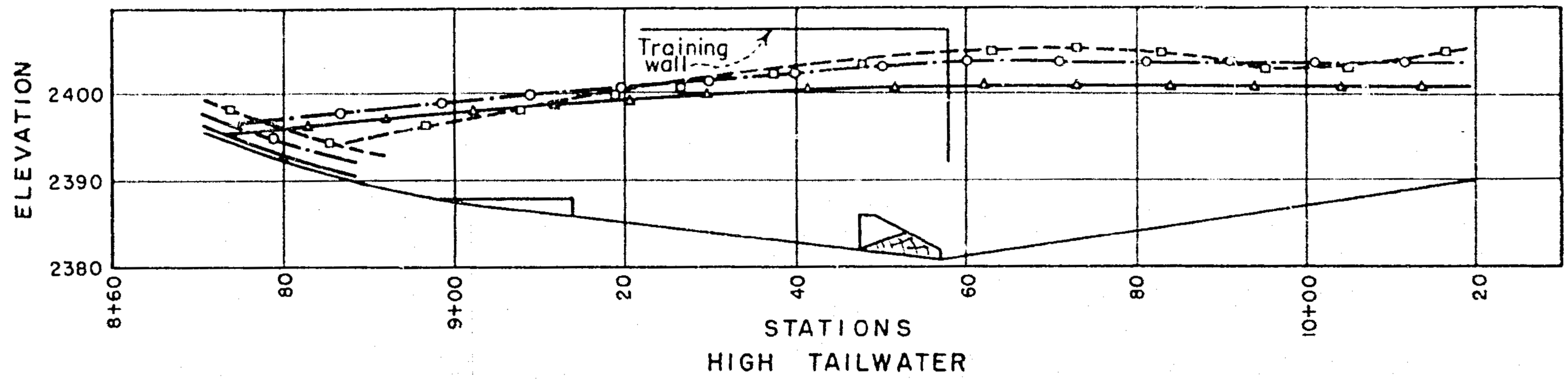
FIGURE 25

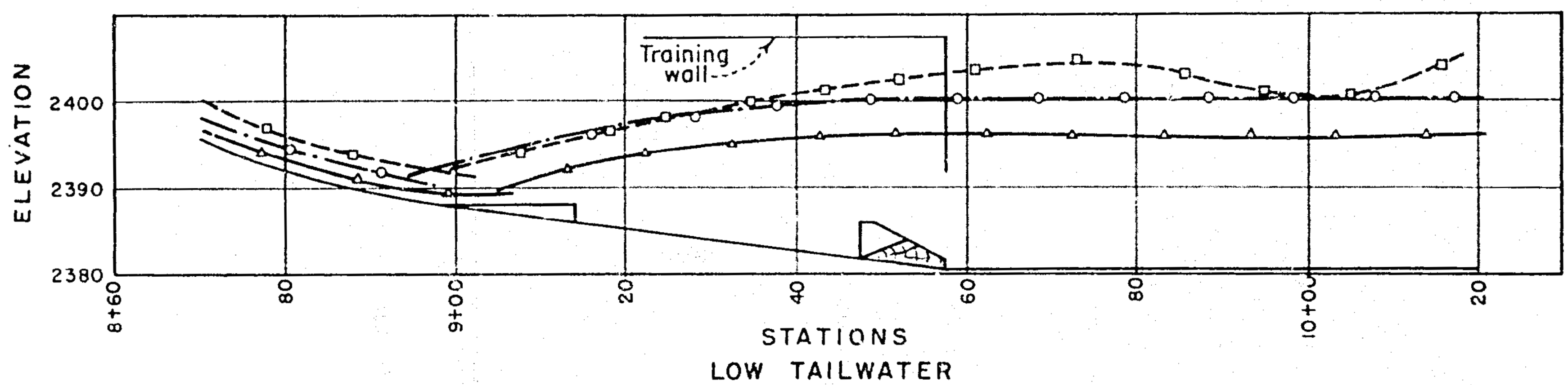


A. High tailwater

B. Low tailwater

DICKINSON DAM SPILLWAY
RECOMMENDED STILLING-BASIN DESIGN - SLOPING APRON
DISCHARGE 33,200 SECOND-FEET
1:36 MODEL





SYMBOL-DISCHARGE

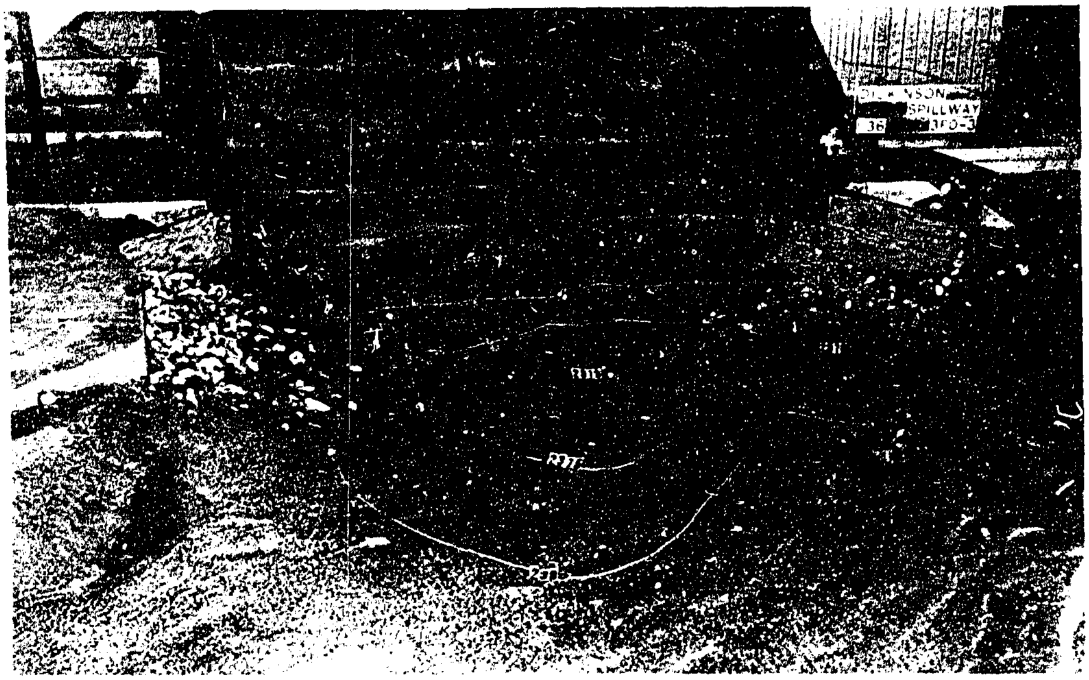
- 10,000 SEC.-FT.
- 20,000 SEC.-FT.
- 33,200 SEC.-FT.

DICKINSON DAM SPILLWAY

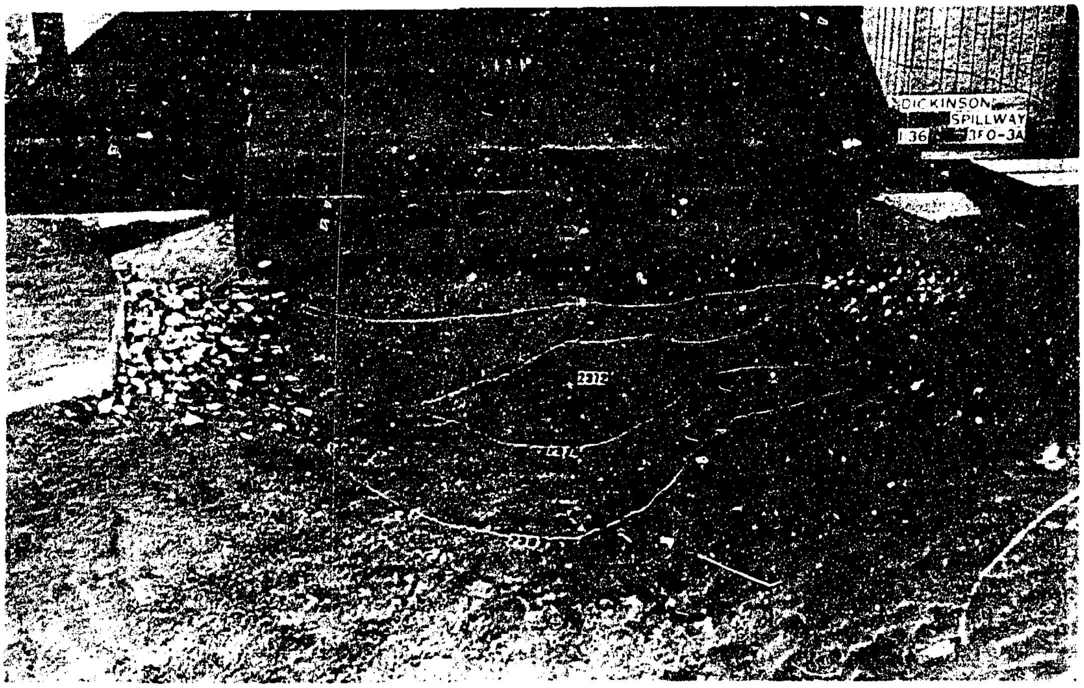
WATER SURFACE PROFILES IN THE RECOMMENDED STILLING BASIN DESIGN-SLOPING APRON

1:36 MODEL

FIGURE 27

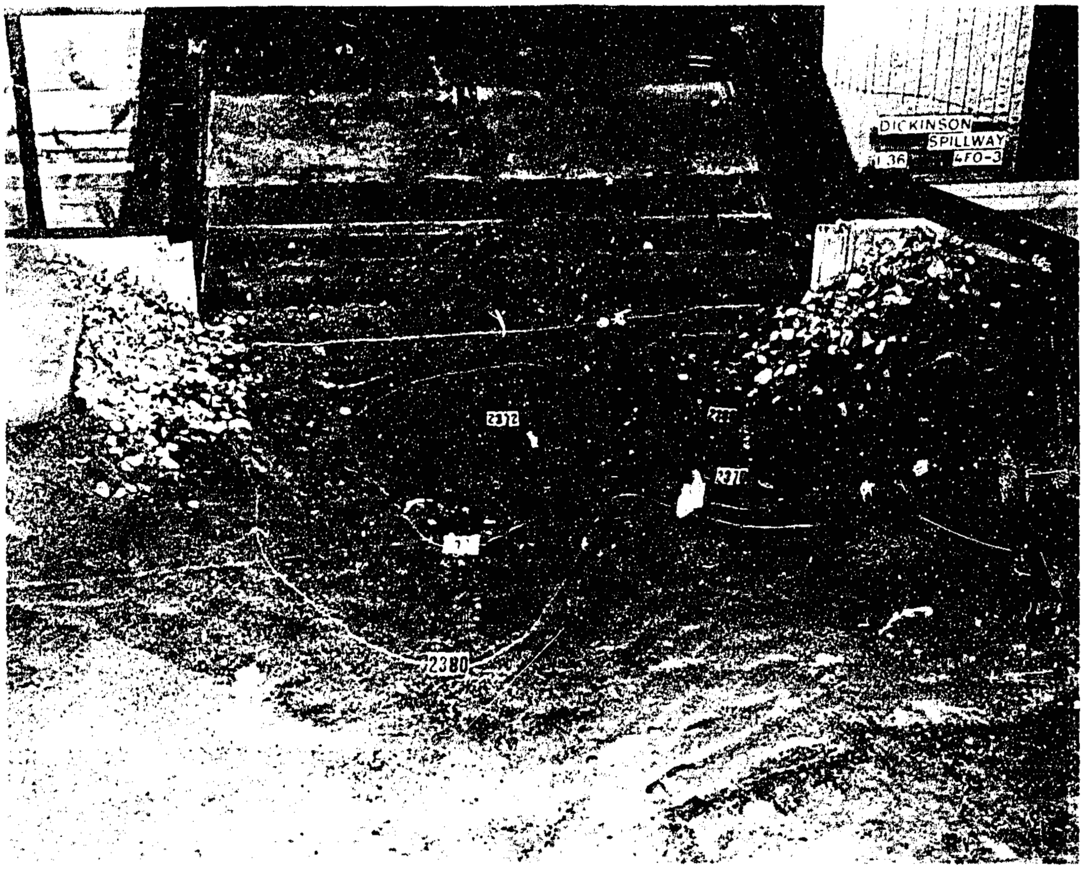


A. Erosion pattern after 2 hours operation of the model with low tailwater



B. Erosion pattern after 2 hours operation of the model with high tailwater

DICKINSON DAM SPILLWAY
RECOMMEND STILLING-BASIN DESIGN - SLOPING APRON
SCOUR FOR 33,200 SECOND-FEET DISCHARGE
1:36 MODEL



Erosion pattern after 2 hours operation of the model with low tailwater

DICKINSON DAM SPILLWAY
EFFECT OF 90° WING-WALLS ON SCOUR PATTERN
DISCHARGE 33,200 SECOND-FEET
1:36 MODEL